

# WIND MICROCLIMATE MODELLING

Anglesea Terrace Residential Development

Anglesea Terrace, Cork

Prepared by: B-Fluid Ltd. | Buildings Fluid Dynamics Consultants

For: Henry J. Lyons

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Engineers	<p>Dr. Cristina Paduano CFD Modelling Specialist CEng MIEI, PhD. Mech Eng., MEng. Aerospace Eng.</p> <table border="1"> <tr> <td>Kamal Pandey CFD Modelling Specialist MSc. Comp. Simulation Sci., BTech. Mech.</td><td>Dr. Sadia Siddiqa CFD Modelling Specialist PhD. Comp. Math., MS, BS</td></tr> </table>	Kamal Pandey CFD Modelling Specialist MSc. Comp. Simulation Sci., BTech. Mech.	Dr. Sadia Siddiqa CFD Modelling Specialist PhD. Comp. Math., MS, BS
Kamal Pandey CFD Modelling Specialist MSc. Comp. Simulation Sci., BTech. Mech.	Dr. Sadia Siddiqa CFD Modelling Specialist PhD. Comp. Math., MS, BS		
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## 1. EXECUTIVE SUMMARY

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B-Fluid Limited has been commissioned by 'Henry J. Lyons' to perform a Wind Microclimate Study for Anglesea Terrace Residential Development at Anglesea Terrace, Old Station Road, Cork.

Figure 1.1 shows a view of the proposed development (colored in red) in the existing urban context.



Figure 1.1: 3D View of Anglesea Terrace Residential Development

The method for the study of wind microclimate combines the use of Computational Fluid Dynamics (CFD) to predict wind velocities and wind flow patterns, with the use of wind data from suitable meteorological station and the recommended comfort and safety standards (Lawson Criteria).

The effect of the geometry, height and massing of the proposed development and existing surroundings including topography, ground roughness and landscaping of the site, on local wind speed and direction is considered as well as the pedestrian activity to be expected (sitting, standing, strolling and fast walking).

The results of the assessment are presented in the form of contours of the Lawson criteria at pedestrian level.

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The assessment has comprised the following scenarios:

- **Baseline Existing Scenario:** This consist of the existing wind microclimate at the site without the proposed development. Figure 1.2 shows a view of the existing surrounding buildings (in grey) and existing development (in red).



Figure 1.2: Buildings in the Baseline Scenario (Existing buildings in grey)

- **Proposed Development Scenario:** This consist of the assessment of the wind microclimate of the site with the proposed development surrounded by existing buildings. Figure 1.3 shows a view of the buildings in the proposed development (colored in red) and existing surrounding buildings (in grey).



Figure 1.3: Buildings in the Proposed Scenario (Proposed development in red, existing buildings in grey)

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Based on the analysis conducted, it can be concluded that:

- The wind profile was built using the annual average of meteorology data collected at Cork Airport Weather Station purchased from Meteoblue. The local wind speed was determined from CFD simulations with combination of the parameters inside Weibull probability distribution function, which was obtained from historical meteorological data recorded 10m above ground level at Cork Airport.
- A 12-discrete set of wind direction is used in order to evaluate the probability of exceedance at any given threshold velocity. It is found that the prevailing wind direction in the south-west has the largest contribution of the discomfort exceedance probability.
- Microclimate Assessment of Anglesea Terrace Residential Development and its environment was performed utilizing a CFD (Computational Fluid Dynamics) methodology.
- The evaluation of the proposed scenario indicates that the planned development aligns with the Lawson Comfort Criteria, confirming that no areas are unsafe and the proposed development does not create conditions of distress. All the ground amenities outlined in the report can be utilized according to their intended scope.
- The analysis of wind speed results and Lawson map at a height of 1.5 meters above the terrace reveals that both terraces (Terraces I and II) are suitable for sitting/standing. It is important to note that fluctuations in velocity on rooftop terraces may lead to door slamming issues. Therefore, it is recommended to consider such conditions in terrace design. Possible means of reducing the risk of door slamming include installing door actuators, using automatic or sliding doors, etc.
- The Lawson Comfort and Distress Map at 1.5m above the balconies indicates that all balconies are safe for occupants, with no identified areas of distress. Wind conditions vary considerably by direction and season, so this should not pose a consistent issue for occupant use. On less favorable days, resident amenities can also serve as an alternative option for outdoor comfort.
- The following mitigation measures will be implemented to further improve pedestrian comfort around the development:
  - *Preserving the existing trees along the walkway on the Northeastern side of the development:*  
The presence of these existing trees along the walkway enhances the comfort for pedestrians.
  - *Introducing plants on the southern entrance and southwestern part of the development:*  
These additional plants will help reduce wind speed, increasing comfort levels in all ground amenities of the development.
  - *A sedum roof on the 4th floor is already a great addition and incorporating some additional planting on Level 7 is also advisable.*  
The introduction of terrace gardens and small plants will further improve the wind comfort level on the terraces and also help reduce corner effects.

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- As a result of the proposed development construction, the wind on the surrounding urban context remains suitable for the intended use when compared with the baseline situation.
- The proposed development does not impact or give rise to negative or critical wind speed profiles at the nearby adjacent roads, or nearby buildings. Moreover, in terms of distress, no critical conditions were found for “Frail persons or cyclists” and for members of the ”General Public” in the surrounding of the development.

Therefore, the CFD study carried out has shown that under the assumed wind conditions typically occurring within Cork for the past 15 years:

- **The development is designed to be a high-quality environment for the scope of use intended of each areas/building (i.e. comfortable and pleasant for potential pedestrian).**
- **The development does not introduce any critical impact on the surrounding buildings, or nearby adjacent roads.**

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## 2. INTRODUCTION

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B-Fluid Limited has been commissioned by 'Henry J. Lyons' to perform a Wind Microclimate Study for Anglesea Terrace Residential Development at Anglesea Terrace, Old Station Road, Cork.

Figure 2.1 shows a view of the proposed development (colored in red) in the existing urban context.

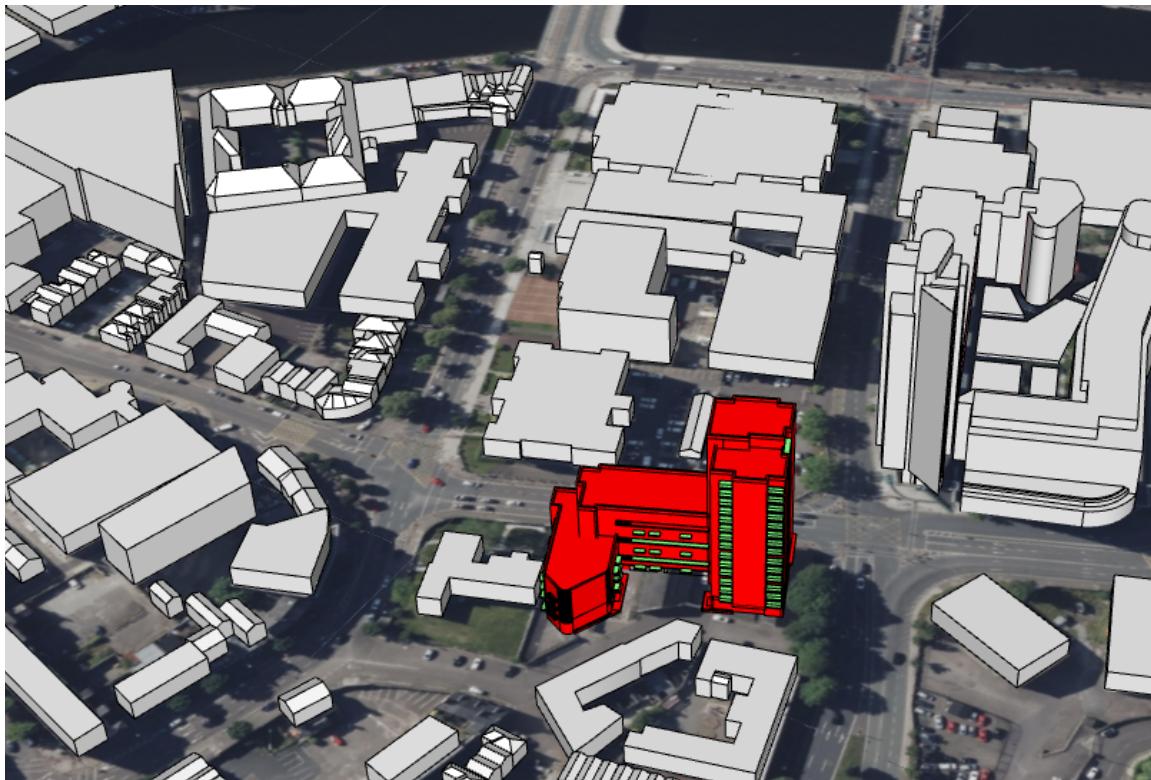


Figure 2.1: Anglesea Terrace Residential Development (colored in red) and Existing Buildings (colored in grey)

This report is completed by Dr. Cristina Paduano, Kamal Pandey, and Dr. Sadia Siddiqa.

Dr. Cristina Paduano is a Chartered Engineer (CEng) and member of Engineers Ireland who specialises in computational fluid dynamics applications for urban environment and the construction industry with over 18 years experience. She holds a PhD in Mechanical Engineering from Trinity College Dublin, with M.Eng and B.Eng in Aerospace Engineering.

Kamal Pandey is a member of Engineers Ireland and CFD modelling specialist engineer. He holds a Master of Science in Computer Simulation in Science with specialization in Computational Fluid Mechanics and a B.Tech in Mechanical Engineering.

Dr. Sadia Siddiqa is a CFD Modelling Engineer specialising in computational fluid dynamics applications. With expertise in modeling fluid flows, airflow patterns, and heat/mass transfer, she's skilled at applying her knowledge to solve real-world challenges in fluid dynamics. She holds a PhD in Computational Mathematics from COMSATS University, where her research focused on CFD applications.

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A wind microclimate study considers the possible wind patterns formed under both mean and peak wind conditions typically occurring on the site area, accounting for a scenario where the proposed development is inserted in the existing environment (potential impact) and, for a scenario where the proposed development is analysed together with the existing environment and any permitted development (not constructed yet) that can be influenced by the wind patterns generated by the proposed one (cumulative impact).

The potential receptors include those areas, in the surrounding of the development, which can be exposed to potential risks generated by the elevated wind speed or building massing wind effects. In particular:

- Amenity areas (pedestrian level), areas likely to be utilised for leisure purposes and as such should be comfortable surroundings.
- Pedestrian routes and seating areas – to determine if locations are comfortable for leisure activities.
- Entrance to the buildings – to determine if there is potential for pressure related issues for entrances or lobbies.
- Landscaped areas – where there are sheltered areas.
- Impact to existing or adjoining developments – where the proposed buildings will cause discomfort conditions through proximity related issues.

The acceptance criteria which define the acceptable wind velocities in relation to the perception of comfort level experienced while carrying out a specific pedestrian activity is known as the “Lawson Criteria for Pedestrian Comfort and Distress”. A wind microclimate study analyzes the wind flow in an urban context (considering the wind conditions typically occurring on the site during a typical year) to develop the so called “Lawson Comfort and Distress Map”; the map identifies where a specific pedestrian activity can be carried out comfortably during most of the time.

The assessment can be performed by physical testing in wind tunnels or by performing “virtual wind tunnel testing” through numerical simulation using Computational Fluid Dynamics (CFD), as done for this project. The scope of the numerical study is to simulate the wind around the development, in order to predict the wind speeds the pedestrians will be exposed to and the level of comfort they will experience when carrying out a specific activity (i.e. walking, strolling, sitting).

The following sections details the methodology, acceptance criteria, CFD wind simulations and the impact of the proposed development on the local wind microclimate against best practice guidelines for pedestrian comfort and safety.

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## 2.1 GUIDANCE and LEGISLATION

According to the ‘Urban Development and Building Heights, Guidelines for Planning Authorities (Government of Ireland, December 2020)’ document, specific wind impact assessment of the microclimatic effects should be performed for ‘buildings taller than prevailing building heights in urban areas’. In the same guidance, standard buildings height is considered 6 storeys. Above this height, buildings are considered ‘taller’ for Cork standards.

The recommended approach to wind microclimate studies is outlined in the “Wind Microclimate Guidelines for Developments in the City of London ‘(August 2019) and in the guidelines and recommendations contained in BRE Digest (DG) 520, “Wind Microclimate Around Buildings” (BRE, 2011). The Lawson Criteria of Comfort and Distress is used to benchmark the pedestrian wind microclimate.

The document also indicates how to use Computational fluid dynamics (CFD) to assess wind microclimate conditions and how to generate high quality outputs to provide a good understanding of the fundamental flow features around an urban context.

Usually, the recommended approach to wind microclimate studies is based on the building height, as presented in Figure 2.2.

Building Height	Recommended Approach to Wind Microclimate Studies
Similar or lower than the average height of surrounding buildings	Wind studies are not required, unless sensitive pedestrian activities are intended (e.g. around hospitals, transport hubs, etc.) or the project is located on an exposed location
<b>Up to 25m</b>	
Up to double the average height of surrounding buildings	Computational Fluid Dynamics (CFD) Simulations <b>OR</b> Wind Tunnel Testing
<b>25m to 50m</b>	
Up to 4 times the average height of surrounding buildings	Computational Fluid Dynamics (CFD) Simulations <b>AND</b> Wind Tunnel Testing
<b>50m to 100m</b>	
High Rise	Early-Stage Massing Optimization: Wind Tunnel Testing <b>OR</b> Computational Fluid Dynamics (CFD) Simulations
<b>Above 100m</b>	Detailed Design: Wind Tunnel Testing <b>AND</b> Computational Fluid Dynamics (CFD) Simulations

Figure 2.2: Recommended Approach to Wind Microclimate Studies based on Building Height, as prescribed by the Wind Microclimate Guidelines for Developments in the City of London (August 2019)

## 2.2 URBAN WIND EFFECTS

Buildings and topography affect the speed and direction of wind flows. Wind speed increases with increasing height above the ground, assuming a parabolic profile.

Flow near the ground level encounters obstacles represented by terrain roughness/buildings that reduce the wind speed and introduce random vertical and horizontal velocity components. This turbulence causes vertical mixing between the air moving horizontally at one level, and the air at those levels immediately above and below it. For this reason, the wind velocity profile is given by a fluctuating velocity along a mean velocity value. Figure 2.3 shows the wind velocity profile, as described above.

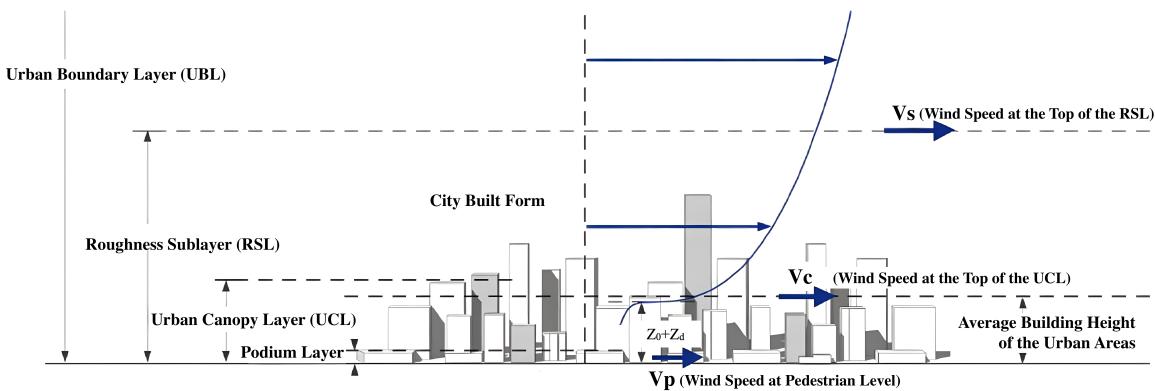


Figure 2.3: Wind Velocity Profile

In an urban context, wind speeds at pedestrian level are generally low compared with upper-level wind speeds, however, the wind can create adverse patterns when flowing in between buildings which can cause local wind accelerations or re-circulations. This wind patterns effect pedestrian safety and comfort. In general, the wind effects to be avoided/mitigated in an urban context include the following:

- **Funnelling Effects:** The wind can accelerate significantly when flowing through a narrow passage between building structures. The highest speeds are experienced at the point where the restriction of the area is the greatest.
- **Downwash Effects:** The air stream when striking a tall building can flow around it, over it and a part can be deflected towards the ground. This downward component is called downwash effect and its intensity depends on the pressure difference driving the wind. The higher the building, the higher this pressure difference can be.
- **Corner Effects:** Wind can accelerate around the corners of the buildings. Pedestrians can experience higher wind speeds as well as more sudden changes in wind speeds. The reason for this is that there are narrow transition zones between the accelerated flows and the adjacent quiescent regions. This effect is linked to the downwash effect as the downward stream component subsequently flows around the corners towards the leeward side of the building.

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- **Wake Effect:** Excessive turbulence can occur in the leeward side of the building. This can cause sudden changes in wind velocity and can raise dust or lead to accumulation of debris. This effect is also dependent on the height of the building.

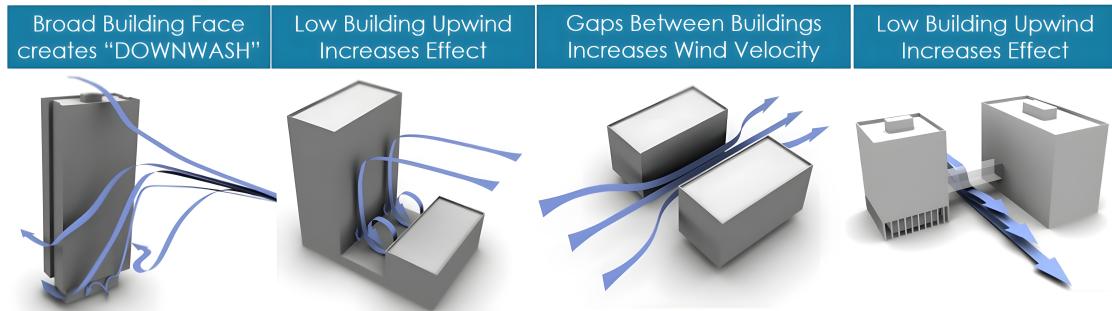


Figure 2.4: Parameters to know for Wind Conditions Assessment

The anticipation of the likely wind conditions resulting from new developments are important considerations in the context of pedestrian comfort and the safe use of the public realm. While it is not always practical to design out all the risks associated with the wind environment, it is possible to provide local mitigation to minimise risk or discomfort where required.

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### 3. ASSESSMENT METHODOLOGY

### 3.1 METHOD OF ASSESSMENT

The method for the study of wind microclimate combines the use of Computational Fluid Dynamics (CFD) to predict wind velocities and wind flow patterns, with the use of wind data from suitable meteorological station and the recommended comfort and safety standards (Lawson Criteria). The effect of the geometry, height and massing of the proposed development and existing surroundings including topography, ground roughness and landscaping of the site, on local wind speed and direction is considered as well as the pedestrian activity to be expected (sitting, standing, strolling and fast walking). The results of the assessment are presented in the form of contours of the Lawson criteria at pedestrian level.

The assessment has comprised the following scenarios:

- **Baseline Existing Scenario:** this consists of the existing wind microclimate at the site without the proposed development.
- **Proposed Development in the Existing Scenario:** this consists of the assessment of the wind microclimate of the site with the proposed development surrounded by existing buildings.

In accordance with the guideline cited in section 2.1, the wind microclimate study should consider the effect of the proposed development together with buildings (existing and/or permitted) that are within 600m from the centre of the site, as shown in Figure 3.1. Other taller buildings outside of this zone that could have an influence on wind conditions within the project site should be included for wind directions where they are upwind of the project site.

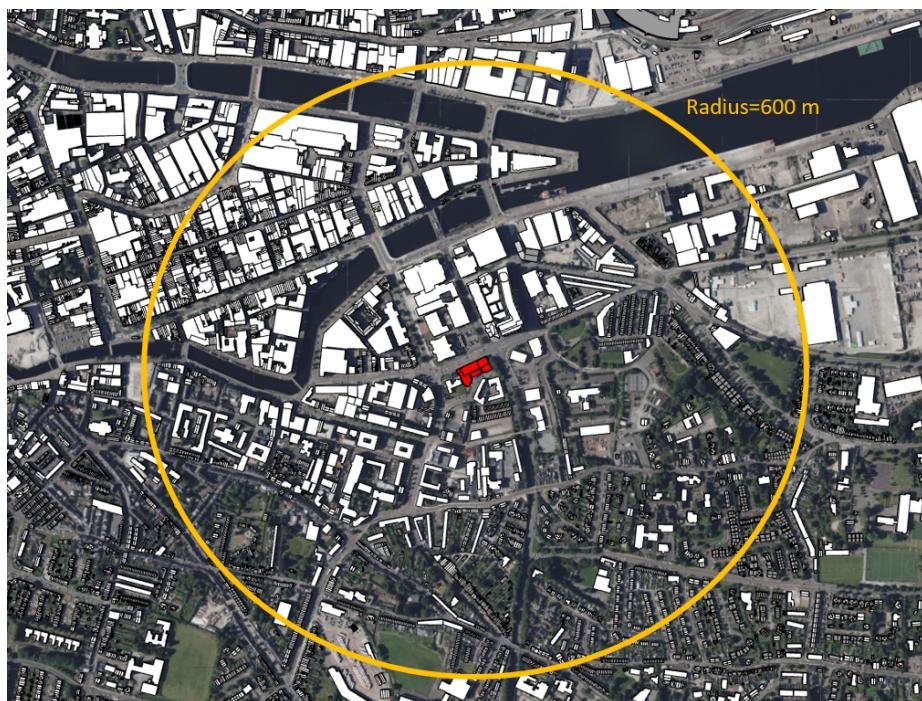


Figure 3.1: Area of interest to be modelled

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In particular, the following has been undertaken:

- Topography of the site with buildings (proposed and adjacent existing/permited developments massing, depending on the scenario assessed “baseline or proposed”) have been modelled using OpenFOAM Software.
- Suitable wind conditions have been determined based on historic wind data. Criteria and selected wind scenarios included means and peaks wind conditions that need to be assessed in relation to the Lawson Criteria.
- Computational Fluid Dynamics (CFD) has been used to simulate the local wind environment for the required scenarios (“baseline, proposed”).
- The impact of the proposed development massing on the local wind environment has been determined (showing the wind flows obtained at pedestrian level).
- Potential receptors (pedestrian areas) have been assessed through review of external amenity/public areas (generating the Lawson Comfort and Distress Map).
- Potential mitigation strategies for any building related discomfort conditions (where necessary) have been explored and their effect introduced in the CFD model produced.

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### 3.2 ACCEPTANCE CRITERIA

Pedestrian Wind Comfort is measured in function of the frequency of wind speed threshold exceeded based on the pedestrian activity. The assessment of pedestrian level wind conditions requires a standard against which measured or expected wind velocities can be compared.

Only gust winds are considered in the safety criterion. These are usually rare events, but deserve special attention in city planning and building design due to their potential impact on pedestrian safety. Gusts cause the majority of cases of annoyance and distress and are assessed in addition to average wind speeds. Gust speeds should be divided by 1.85 and these "gust equivalent mean" (GEM) speeds are compared to the same criteria as for the mean hourly wind speeds. This avoids the need for different criteria for mean and gust wind speeds.

The following criteria are widely accepted by municipal authorities as well as the international building design and city planning community:

- **DISCOMFORT CRITERIA:** Relates to the activity of the individual.  
Onset of discomfort:
  - Depends on the activity in which the individual is engaged and is defined in terms of a mean hourly wind speed (or GEM) which is exceeded for 5% of the time.
- **DISTRESS CRITERIA:** Relates to the physical well-being of the individual.  
Onset of distress:
  - 'Frail Person Or Cyclist': equivalent to an hourly mean speed of 15 m/s to be exceeded more than 0.023% per year. This is intended to identify wind conditions which less able individuals or cyclists may find physically difficult. Conditions in excess of this limit may be acceptable for optional routes and routes which less physically able individuals are unlikely to use.
  - 'General Public': A mean speed of 20 m/s or larger speed to be exceeded more than 0.023% per year, when aerodynamic forces approach body weight makes it impossible for anyone to remain standing. If wind speeds exceed these values, pedestrian access should be discouraged.

The above criteria set out six pedestrian activities and reflect the fact that calm activity requires calm wind conditions, which are summarised by the Lawson scale, shown in Figure 3.2. Lawson scale assesses pedestrian wind comfort in absolute terms and defines the reaction of an average person to the wind. Each wind type is associated to a number, corresponding to the Beaufort scale. Beaufort scale is an empirical measure that relates wind speed to observed conditions at sea or on land. A 20% exceedance is used in these criteria to determine the comfort category, which suggests that wind speeds would be comfortable for the corresponding activity at least 80% of the time or four out of five days.

Beaufort Scale	Wind Type	Mean Hourly Wind Speed (m/s)		Acceptance Level Based on Activity–Lawson Criteria			
				Sitting	Standing/ Entrances	Leisure Walking	Business Walking
0-1	Light Air	0 – 1.55	COMFORT				
2	Light Breeze	1.55 – 3.35					
3	Gentle Breeze	3.35 – 5.45					
4	Moderate	5.45 – 7.95					
5	Fresh Breeze	7.95 – 10.75					
6	Strong Breeze	10.75 – 13.85					
7	Near Gale	13.85 – 17.15					
8	Gale	17.15 – 20.75					
9	Strong Gale	20.75 – 24.45					
Legend							
							

Figure 3.2: Lawson Scale

These criteria for wind forces represent average wind tolerances. They are subjective and variable depending on thermal conditions, age, health, clothing, etc. which can all affect a person's perception of a local microclimate. Moreover, pedestrian activity alters between winter and summer months. The criteria assume that people will be suitably dressed for the time of year and individual activity. It is reasonable to assume, for instance, that areas designated for outdoor seating will not be used on the windiest days of the year. Weather data measured are used to calculate how often a given wind speed will occur each year over a specified area.

Pedestrian comfort criteria are assessed at 1.5m above ground level. Unless in extremely unusual circumstances, velocities at pedestrian level increase as you go higher from ground level.

A breach of the distress criteria requires a consideration of:

- whether the location is on a major route through the complex,
- whether there are suitable alternate routes which are not distressful.

If the predicted wind conditions exceed the threshold, then conditions are unacceptable for the type of pedestrian activity and mitigation measure should be implemented into the design.

Pedestrian Comfort Category (Lawson Scale)	Mean and Gem wind speed not to be exceeded more than 5% of the time	Description
Long-Term Sitting	4m/s	Acceptable for frequent outdoor sitting use, i.e., restaurant /café
Standing	6m/s	Acceptable for occasional outdoor sitting use, i.e., public outdoor spaces
Walking/Strolling	8m/s	Acceptable for entrances/bus stops /covered walkaways
Business Walking	10m/s	Acceptable for external pavements, walkways
Unacceptable/Distress	>10m/s	Start of not comfortable/distress level for pedestrian access

Figure 3.3: Lawson Categories Scale - Comfort

Pedestrian Safety Category (Lawson Scale)	Mean and Gem wind speed not to be exceeded more than 0.0022% of the time	Description
Unsafe for public	>20m/s	Distress/safety concern for pedestrian
Unsafe for cyclists or frail person	>15m/s	Distress/safety concern for cyclist/frail person

Figure 3.4: Lawson Categories Scale - Distress/Safety

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### 3.3 SIGNIFICANCE CRITERIA

The significance of on-site measurement locations are defined by comparing the wind comfort/safety levels with the intended pedestrian activity at each location, using the table provided by the Lawson Comfort and Distress Criteria.

The significance of off-site measurement locations are defined by comparing the wind comfort/safety levels with the intended pedestrian activity at each location, prior and after the introduction of the proposed development.

Significance	Trigger	Mitigation required?
Major Adverse	Conditions are “unsafe”	Yes
Moderate Adverse	Conditions are “unsuitable” (in terms of comfort) for the intended pedestrian use.	Yes
Negligible	Conditions are “suitable” for the intended pedestrian use.	No
Moderate Beneficial	Conditions are calmer than required for the intended pedestrian use (by at least one comfort category).	No

Figure 3.5: Significance Criteria for On-site Receptors

Significance	Trigger	Mitigation required?
Major Adverse	<p>Conditions that were “safe” in the baseline scenario became “unsafe” as a result of the Proposed Development.</p> <p><i>OR</i></p> <p>Conditions that were “suitable” in terms of comfort in the baseline scenario became “unsuitable” because of the Proposed Development.</p> <p><i>OR</i></p> <p>Conditions that were “unsafe” in the baseline scenario are made worse because of the Proposed Development.</p>	Yes
Moderate Adverse	Conditions that were “suitable” in terms of comfort in the baseline scenario are made windier (by at least one comfort category) as a result of the Proposed Development but remain “suitable” for the intended pedestrian activity.	No
Negligible	Conditions remain the same as in the baseline scenario.	No
Major Beneficial	Conditions that were “unsafe” in the baseline scenario became “safe” because of the Proposed Development.	No
Moderate Beneficial Potential Receptors	<p>Conditions that were “unsuitable” in terms of comfort in the baseline scenario became “suitable” because of the Proposed Development.</p> <p><i>OR</i></p> <p>Conditions that were “unsafe” in the baseline scenario are made better as a result of the Proposed Development (but not so as to make them “safe”).</p>	No

Figure 3.6: Significance Criteria for Off-site Receptors

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## 4. CFD MODELLING METHOD

## 4.1 INTRODUCTION OF CFD TECHNIQUE

Computational Fluid Dynamics (CFD) is a numerical technique to simulate fluid flow, heat and mass transfer, chemical reaction and combustion, multiphase flow, and other phenomena related to fluid flows. CFD modelling includes three main stage: pre-processing, simulation and post-processing as described in Figure 4.1. The Navier-Stokes equations, used within CFD analysis, are based entirely on the application of fundamental laws of physics and therefore produce extremely accurate results providing that the scenario modelled is a good representation of reality.

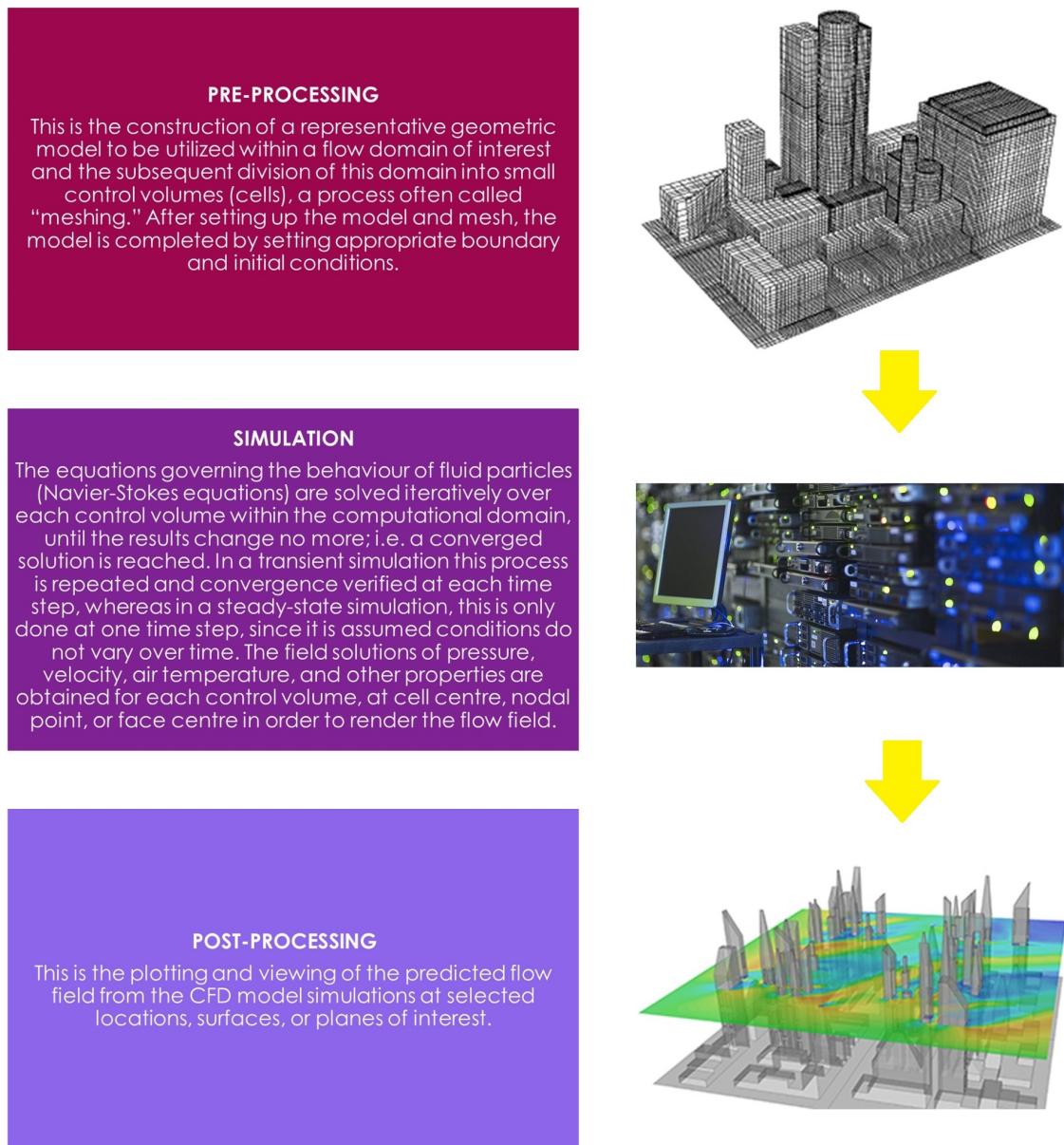


Figure 4.1: CFD Modelling Process Explanation

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## 4.2 CFD SOFTWARE DETAILS

This report employs OpenFOAM Code, based on the concept of Reynolds-Averaged Navier-Stokes (RANS) formulations and the post-processing visualisation tool ParaView. OpenFOAM is a CFD software released and developed primarily by OpenCFD Ltd, since 2004. It has a large user base across most areas of engineering and science, from both commercial and academic organisations. OpenFOAM has an extensive range of features to solve anything from complex fluid flows involving chemical reactions, turbulence and heat transfer, to acoustics, solid mechanics and electromagnetics.

## 4.3 CFD MODEL DETAILS

### FLOW ASSUMPTIONS & TURBULENCE MODELLING

In this study, the air flow is assumed to be incompressible, Newtonian, and statistically steady with temperature and gravity effects neglected. The flow is governed by the Reynolds-Averaged Navier-Stokes (RANS) formulation for mass and momentum where the turbulence is modeled using the  $k-\omega$  SST turbulence model.

### MODELED GEOMETRIES

The extent of the built area (e.g. buildings, structures or topography) that is represented in the numerical domain depends on the influence of the features on the region of interest. According to the Best Practice Guideline (COST Action 732), a building with height  $H$  (height of the tallest proposed building is  $\approx 86$  m) may have a minimal influence if its distance from the region of interest is greater than  $6-10H$  (we considered 600m which is in that range).

The modelled layout and dimensions of the surrounding environment are outlined in the table below (Table 4.1).

Table 4.1: Modelled Environment Dimensions

	MODELLED CFD ENVIRONMENT DIMENSIONS		
	Width	Length	Height
Computational Domain	Approx. 600m	Approx. 600m	Approx. 300m

A 3D view of the proposed development massing model in the domain is presented in Figure 4.2. Geometries used in this study include two parts:

- The massing model of Anglesea Terrace Residential Development (colored in red), which is generated based on the Revit models provided by Henry J. Lyons;
- The massing model of the building blocks within 600 m from the development (colored in grey).



Figure 4.2: 3D View of the Massing Models of Anglesea Terrace Residential Development (colored in red) and Surrounding Building Blocks (colored in grey)

### COMPUTATIONAL MESH

The computational mesh used in this report is created using OpenFOAM utilities blockMesh and snappyHexMesh. It is a hybrid mesh containing a structured background grid and an unstructured hexahedron-dominated mesh in the near-wall region. The largest cell has a depth of 5 m, where the smallest has a depth of 0.15 m. The total cell count is approx. 115 million. An isometric view of the geometry captured by the computational mesh is shown in Figure 4.3.

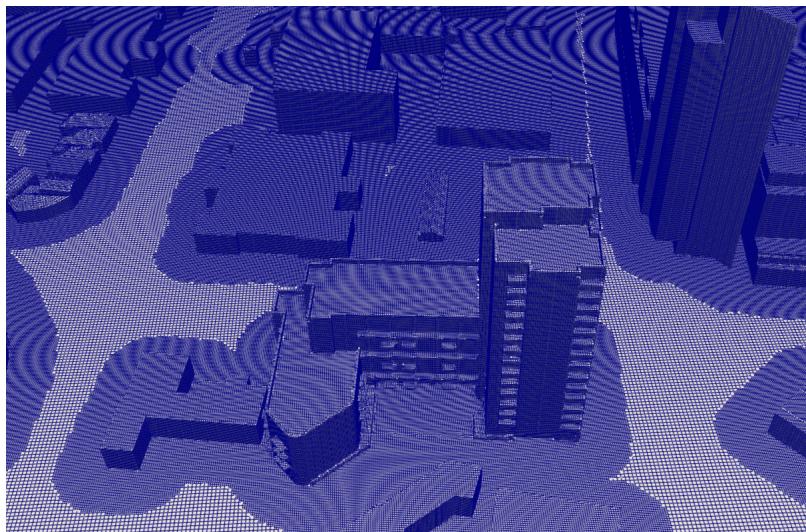


Figure 4.3: Computational Mesh of Anglesea Terrace Residential Development

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## BOUNDARY CONDITIONS

For each wind directions, an initial wind velocity was set based on logarithmic wind profile. Surfaces within the model were specified as having ‘no slip’ condition. This boundary condition, ensures that flow moving parallel to a surface is brought to rest at the point where it meets the surface. All the other domain boundaries are set as ”Open Boundaries”.

The wind velocity data provided by the historical data collection and by the local data measuring are used in the formula below for the logarithmic wind profile to specify the wind velocity profile (wind velocity at different heights) to be applied within the CFD model:

$$u_{(z)} = \frac{u^*}{K} \cdot \ln\left(\frac{z+z_0}{z_0}\right) \quad (4.1)$$

where:

- $u_{(z)}$  = wind speed measured at the reference height  $z$
- $z$  = height to measure  $u_{(z)}$
- $z_0$  = roughness length selected According to Eurocode (2005)
- $u^*$  = friction velocity
- $K$  = Karman constant

## NUMERICAL CONFIGURATIONS

In this study, all simulations employ the SIMPLE algorithm to perform the pressure–velocity coupling (simpleFoam solver in OpenFOAM). All terms in the RANS equations are discretized using the nominally second-order cell-centred finite volume method, where gradient and Laplacian terms are discretized using Gaussian integration with linear interpolation. Convection/advection terms are discretized using a second-order accurate linear-upwind scheme.

## PARALLEL CONFIGURATIONS

The computational mesh was decomposed using the SCOTCH algorithm. All simulations in this study are performed in parallel on an in-house HPC cluster. Key parameters of the CFD model used in this wind microclimate study are summarised in Table 4.2.

Table 4.2: Key parameters of the CFD model for each wind scenario

KEY PARAMETERS OF THE CFD MODEL	
Air Density ( $\rho$ )	1.2 kg/m <sup>3</sup>
Turbulence Model	k- $\omega$ SST Model
Cell Size	Approx. 0.15 m at the development Approx. 0.3 m in the surroundings 5 m elsewhere
Total Cell Count	Approx. 115 million

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## 5. LOCAL WIND CLIMATE

## 5.1 THE EXISTING RECEIVING ENVIRONMENT

In this chapter, wind impact has been assessed on the existing receiving environment considered the existing buildings and the topography of the site prior of the construction of the proposed development. A statistical analysis of 15 years historical weather wind data has been carried out to assess the most critical wind speeds, directions and frequency of occurrence of the same. The aim of this assessment has been to identify the wind microclimate of the area that may cause critical conditions for pedestrians comfort criteria.

### Site Location And Surrounding Area

Anglesea Terrace Residential Development will be situated in Anglesea Terrace, Old Station Road, Cork. The Existing Environment site is shown in Figure 5.1. The area considered for the existing environment and proposed development assessment comprises an Approx. 1.5 km<sup>2</sup> area around Anglesea Terrace Residential Development as represented in Figure 5.2.

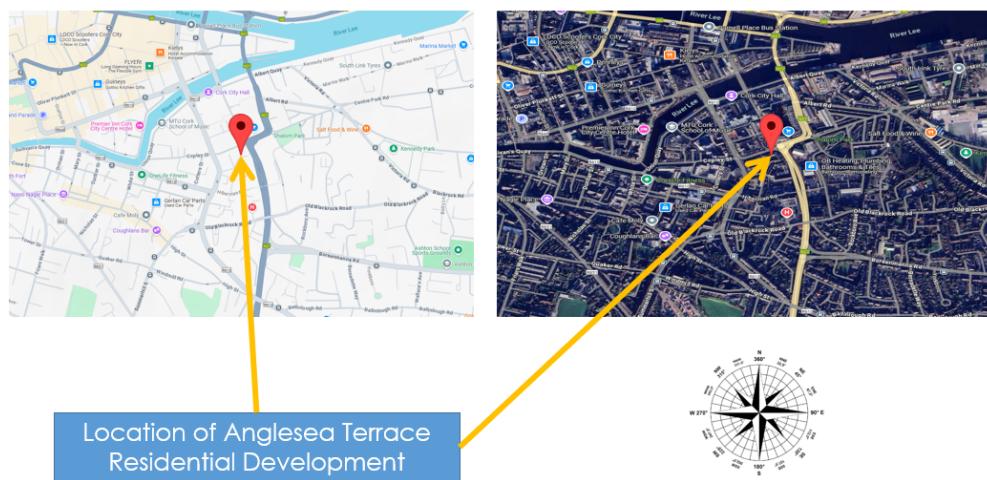


Figure 5.1: Anglesea Terrace Residential Development Site Location and Existing Environment

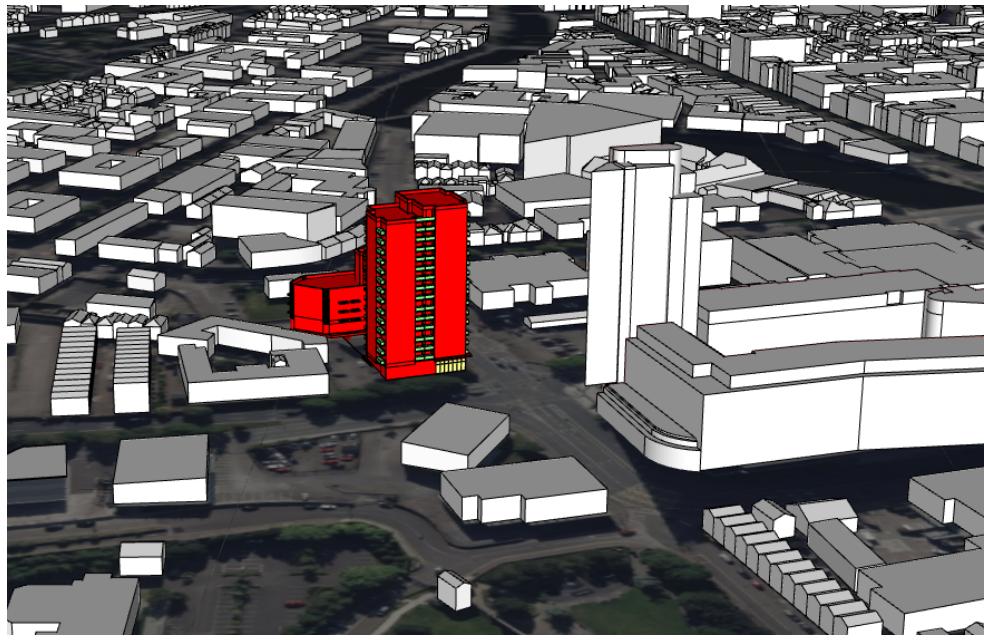


Figure 5.2: Extents of Analysed Existing Environment Around Anglesea Terrace Residential Development

#### Topography And Built In Environment

Figure 5.3 shows an aerial photograph of the terrain surrounding the construction site at Anglesea Terrace Residential Development. Anglesea Terrace Residential Development Site is located in Anglesea Terrace, Cork. Therefore, the area surrounding the site can be characterised as urban environment.

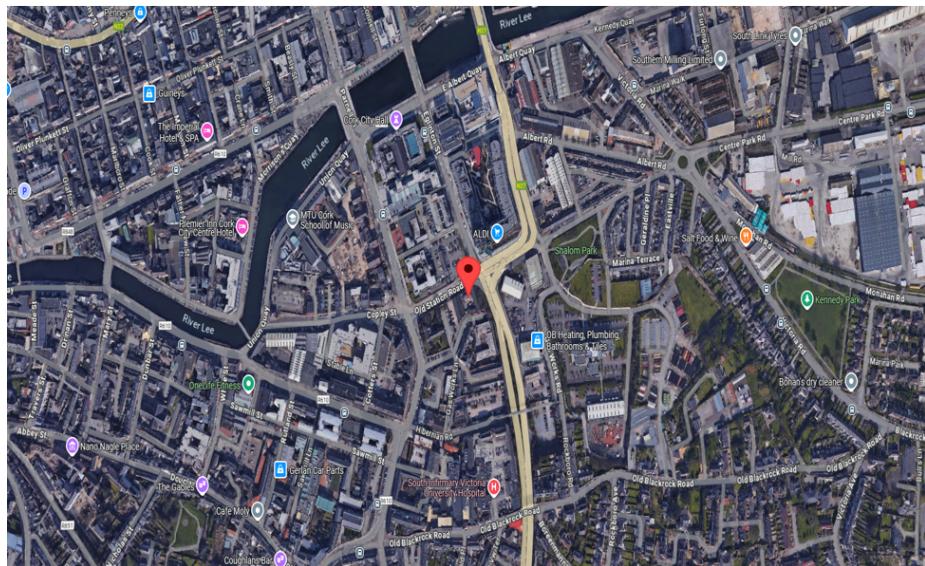


Figure 5.3: Built-in Environment Around Construction Site at Anglesea Terrace Residential Development

## 5.2 LOCAL WIND CONDITIONS

This analysis considers the whole development being exposed to the typical wind condition of the site. The building is oriented as shown in the previous sections. The wind profile is built using the annual average of meteorology data collected at Cork Airport Weather Station. Figure 5.4 shows on the map, the position of Anglesea Terrace Residential Development and the position of Cork Airport.

Regarding the transferability of the available wind climate data, the following considerations have been made:

- *Terrain:* The meteorological station is located on the flat open terrain of the airport, whereas the development site is in an urban area with built-in structures including buildings of around 10 m height in average (warehouses and houses).
- *Wind Directions:* The landscape around the development site can in principle be characterized as flat terrain. Isolated elevations in the near area of the development should have no influence on the wind speed and wind directions. With respect to the general wind climate no significant influence is expected. Based on the above considerations it can be concluded that the data from the meteorological station at Dublin Airport are applicable for the desktop assessment of the wind comfort at the development site.

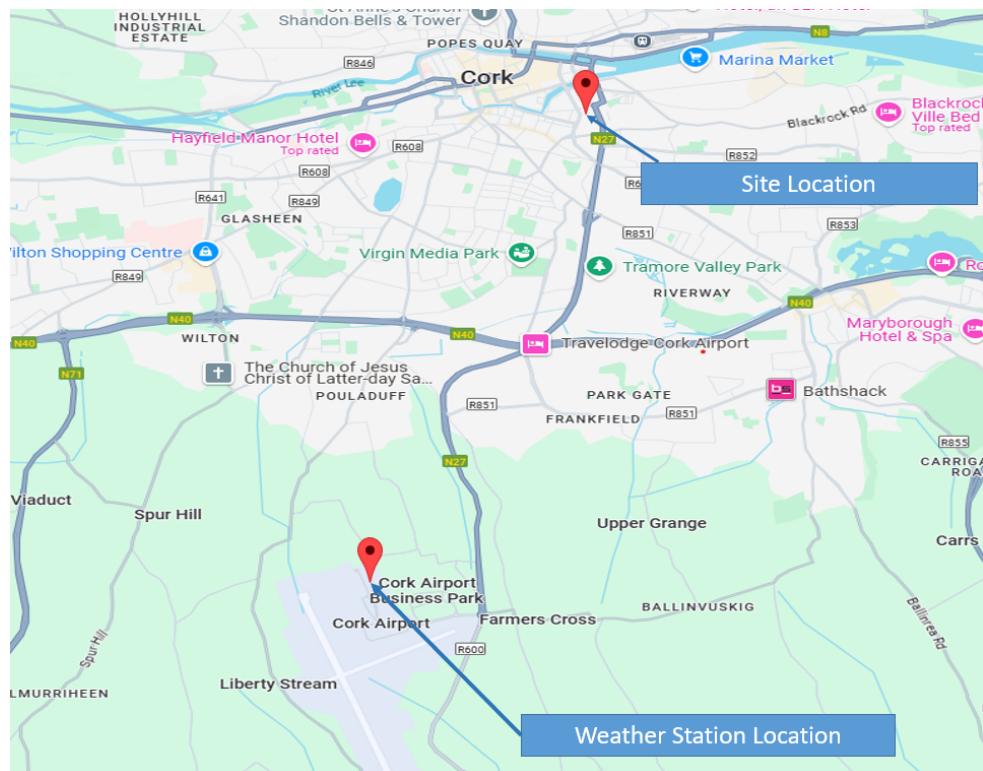


Figure 5.4: Map showing the position of Anglesea Terrace Residential Development and Cork Airport

The assessment of the wind comfort conditions at the new development will be based on a discrete set of wind data throughout a year (annual wind statistic) provided by Meteoblue for Cork airport meteorological wind station. In this study, a 12-discrete set of wind direction is used in order to evaluate the probability of exceedance at any given threshold speed. A Weibull probability distribution is used to fit the given wind data into a continuous one for each wind direction. From Weibull distribution function, the probability, P, can be obtained for each wind direction by:

$$P = e^{(-\frac{U}{c})^k}$$

Where c is the scale parameter and k is the shape parameter for a wind speed U.

Statistical analysis of the number of hours and magnitudes of wind is performed in order to indicate the pedestrian comfort and distress analysis as per Lawson Criteria. Each of the wind directions was interpolated to calculate the probability that a velocity threshold will be exceeded. Based on the criterion of occurrence frequency, if the proposed site is exposed to a wind from a specific direction for more than 5 percent of the time, then the microclimate analysis should consider the impact of this wind (accounting for its direction and most frequent speed) on the local microclimate. However, to get a complete picture, simulations were conducted for wind from 12 distinct directions equally spaced around the development (every 30°).

As stated above, the local wind climate is determined from historical meteorological data recorded at Cork Airport. The data set analyzed for this assessment is based on the meteorological data associated with the maximum daily wind speeds recorded over a 15-year period between 2008 and 2023 at a weather station at the airport, which is located 10m above ground. Figure 5.5 shows the wind speed record during the latest 5 years.



Figure 5.5: Local Wind Conditions - Wind Speed - 2018-2022

Figure 5.6, presenting the wind speed diagram for Cork, shows the days per month, during which the wind reaches a certain speed. It is evident from this figure that strong winds are more prevalent during the winter season (December, January, and February) and the start of spring season (March) compared to other seasons.

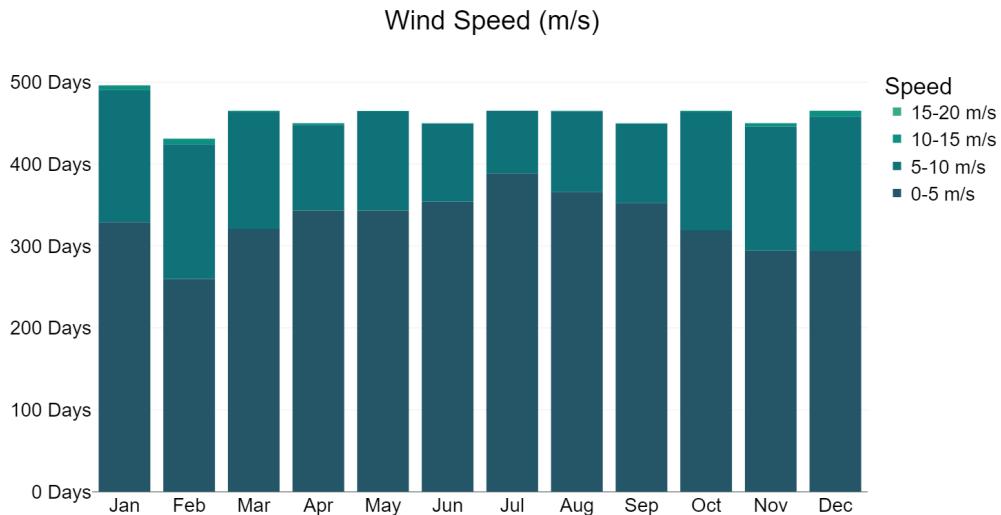


Figure 5.6: Cork Wind Speed Diagram

Figure 5.7 displays the wind rose for Anglesea Terrace Residential Development, revealing the percentage of wind coming from different directions over a 15-year period. Detailed percentages for each direction are outlined in Table 5.1. As depicted in Figure 5.7 and highlighted in Table 5.1, the highest probability of wind occurrence lies in the wind blowing from  $210^{\circ}$  to  $300^{\circ}$  with  $210^{\circ}$  being most prevalent. This finding indicates that south-west winds are the prevailing wind directions and contribute significantly to the probability of discomfort exceedance. In addition, seasonal changes were analysed in order to indicate the prevailing wind directions (Fig 5.8).

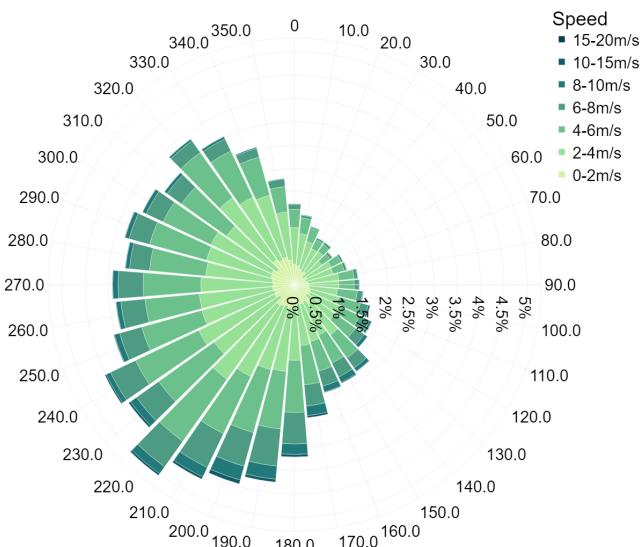


Figure 5.7: Cork Wind Rose

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Table 5.1: A detailed table includes wind occurrences, wind patterns, and roughness lengths for different wind directions.

Wind Direction	Scale Parameter	Shape Parameter	Roughness Length ( $z_0$ )	Frequency
210.00°	1.74	4.10	0.30	13.53%
240.00°	1.63	3.47	0.30	13.51%
270.00°	1.88	3.90	0.30	11.45%
300.00°	2.17	4.27	0.30	11.40%
180.00°	2.08	5.09	0.30	10.85%
330.00°	1.93	3.59	0.30	9.89%
150.00°	1.76	4.15	0.30	6.73%
120.00°	1.74	3.81	0.30	5.79%
0.00°	1.72	3.11	0.30	5.54%
90.00°	1.95	3.59	0.30	4.27%
30.00°	1.70	2.84	0.30	3.54%
60.00°	1.44	2.43	0.30	3.34%

In addition to the annual statistical analysis of wind occurrences (Figure 5.7), a detailed examination has been conducted to comprehend the wind conditions during each season. As illustrated in Figure 5.8, the wind patterns in spring closely resemble those in summer, with a higher percentage of winds coming from the east and north-east compared to the same direction in summer. Although in autumn the wind pattern is similar to winter, during winter, the winds occur more frequently and are stronger. In general, the predominant winds come from the south-west at higher speeds compared to other wind directions throughout all seasons.

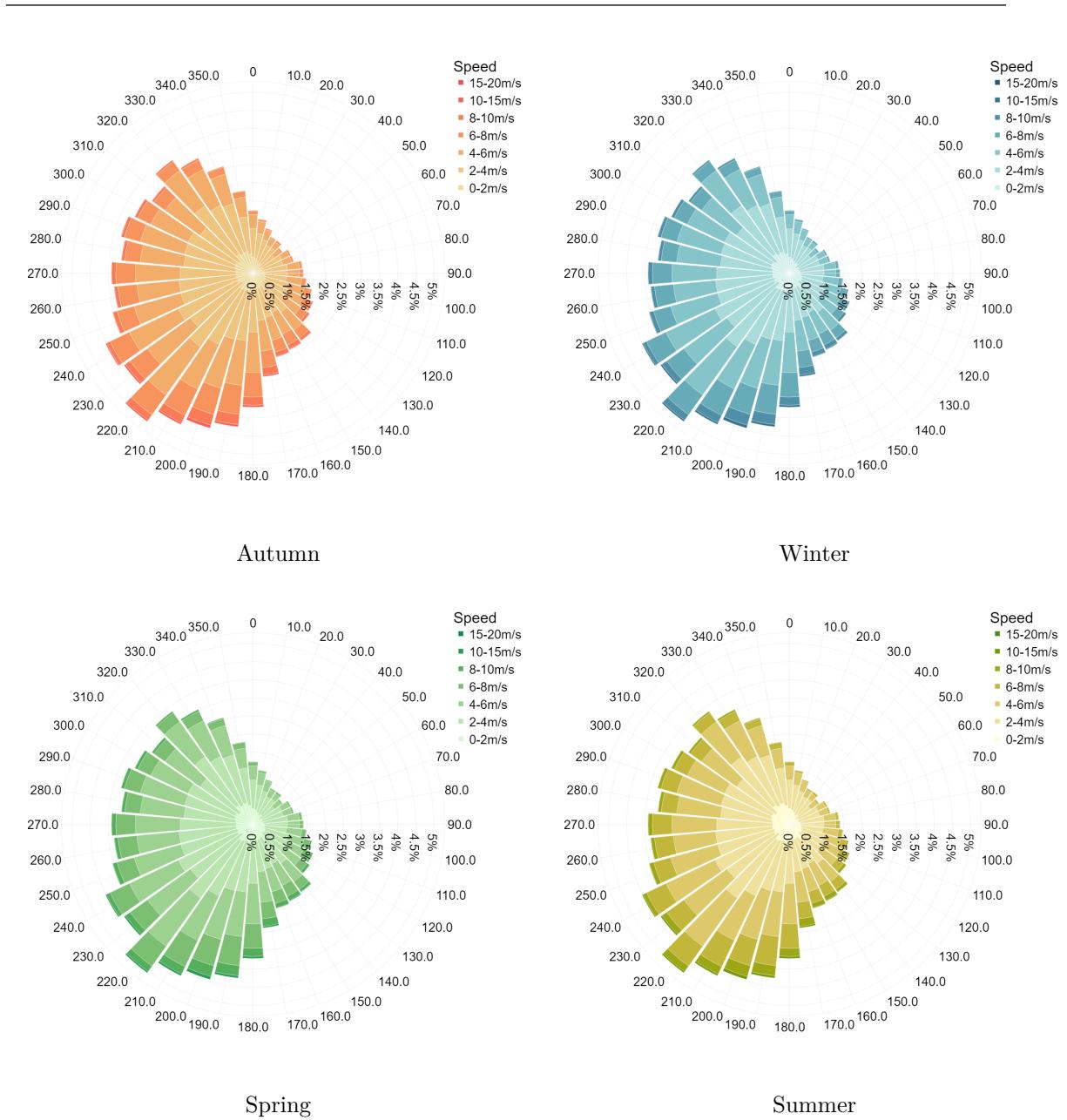


Figure 5.8: Wind speeds and wind directions at different seasons

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## **6. CHARACTERISTICS OF THE PROPOSED DEVELOPMENT**

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## 6.1 DESCRIPTION OF PROPOSED DEVELOPMENT

The development proposes the demolition of existing structures and construction of 147 no. residential units and 3 mixed-use units located at Anglesea Terrace, Old Station Road, Cork. Please refer to the description of development in the Architects Design Statement for further details.

Figures 6.1 and 6.2 show 3D views of the proposed development (colored in red) and existing surround buildings (colored in grey).



Figure 6.1: Anglesea Terrace Residential Development - 3D View

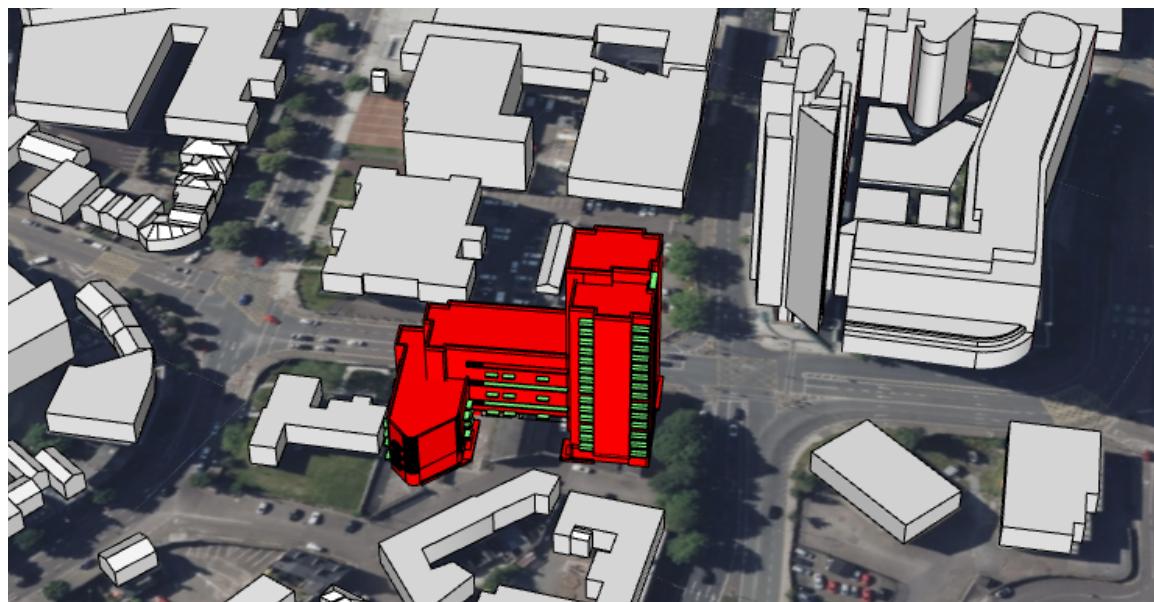


Figure 6.2: Anglesea Terrace Residential Development - 3D View

## 6.2 POTENTIAL RECEPTORS

Potential receptors for the wind assessment are all pedestrian circulation routes, building entrances and leisure open areas within the site and in neighboring adjacent areas. The pedestrian levels are considered at 1.5m above the ground and terraces.

Figures 6.3 shows the pedestrian activity area on the ground and on the terraces (Roman numerals), respectively. These areas are considered as sensitive potential receptors for the wind microclimate analysis.

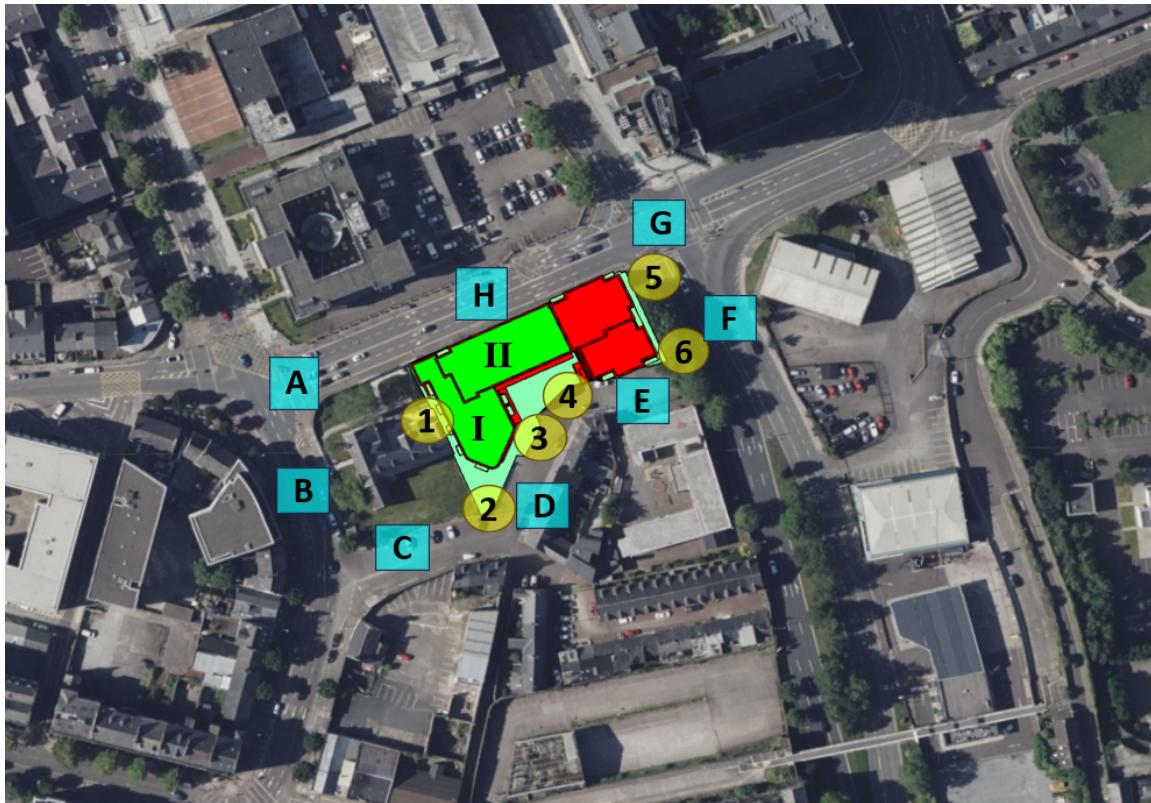


Figure 6.3: Potential Sensitive Receptors on the Ground

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Table 6.1 lists the descriptions of potential receptors as shown in Figures 6.3.

Table 6.1: List of the Receptors

On-Site Potential Receptors ID	Description	Off-Site Potential Receptors ID	Description
1.	Area in the southwest direction	A.	Intersection of Old Station Rd., Anglesea St. and Copley St.
2.	Open Area in Corner	B.	Anglesea Street
3.	Open Area towards the Entrance	C.	Intersection of Anglesea St. and Anglesea Terrace
4.	Entrance	D.	Intersection of Anglesea Terrace and Railway Cottages
5.	Northern Edge Footpath	E.	Anglesea Terrace Cul de Sac
6.	Northeastern Footpath	F.	S City Link Rd
I	Terrace at 4th Floor	G.	Intersection of Old Station Rd, S City Link Rd and Eglinton St.
II	Terrace at 7th Floor	H.	Old Station Road

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## 7. BASELINE WIND MICROCLIMATE

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## 7.1 BASELINE SCENARIO

The wind microclimate of the baseline scenario is defined by the wind patterns that develop on the site and its the surroundings (existing buildings and topography) under the local wind conditions relevant for the assessment of the Pedestrian Comfort and Distress.

In this scenario the assessment has considered the impact of wind on the existing area. Results of wind microclimate at pedestrian level (1.5m height - flow speeds) are collected throughout the modelled site. These flow velocities identify if locally, wind speeds at pedestrian-level are accelerated or decelerated in relation to the undisturbed reference wind speed due to the presence of the existing baseline environment.

The impact of these speeds are then combined with their specific frequency of occurrence and presented in the maps that show the area of comfort and distress in accordance with Lawson Criteria, these maps are produced at pedestrian level on the ground and identify the suitability of each areas to its prescribed level of usage and activity.

### 7.1.1 WIND SPEEDS - Pedestrian Level

Results of wind speeds and their circulations at pedestrian level of 1.5m above the development ground are presented in Figures 7.1 to 7.12 in order to assess wind flows at ground floor level of Anglesea Terrace Residential Development.

Wind flow speeds are shown to be within tenable conditions. Higher velocity and recirculation effects are found in the existing site.

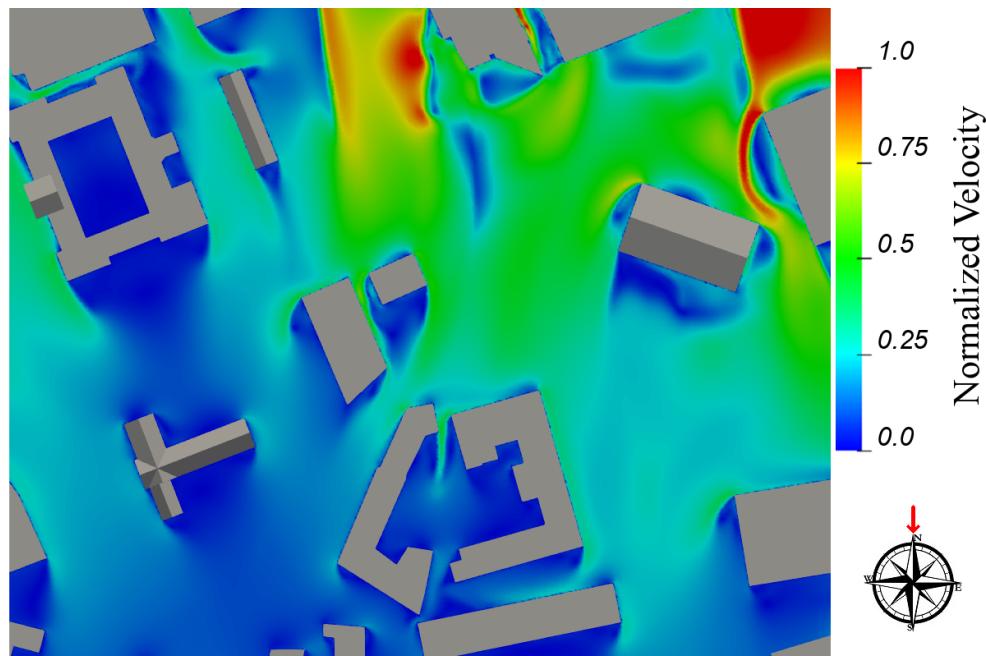


Figure 7.1: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 0°

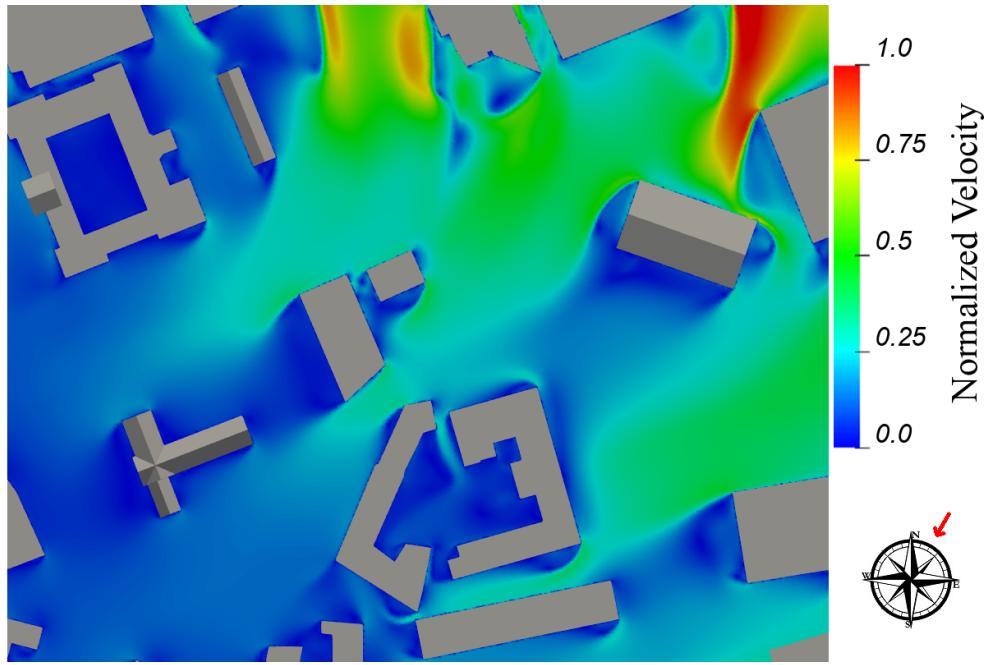


Figure 7.2: Ground Floor Level - Flow Velocity Results at  $Z=1.5\text{m}$  above the ground - Wind Direction:  $30^\circ$

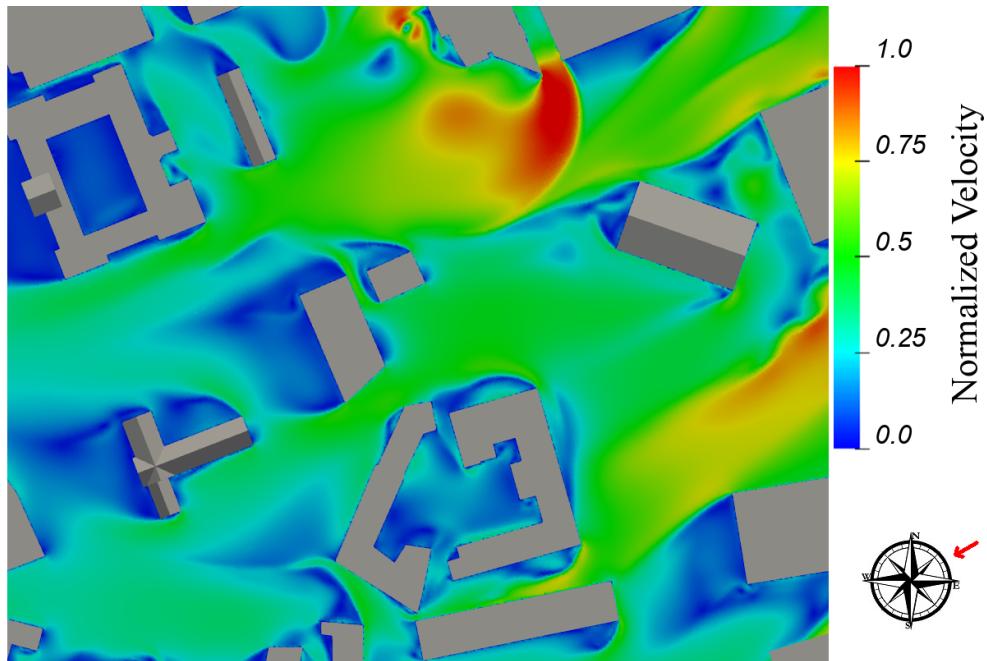


Figure 7.3: Ground Floor Level - Flow Velocity Results at  $Z=1.5\text{m}$  above the ground - Wind Direction:  $60^\circ$

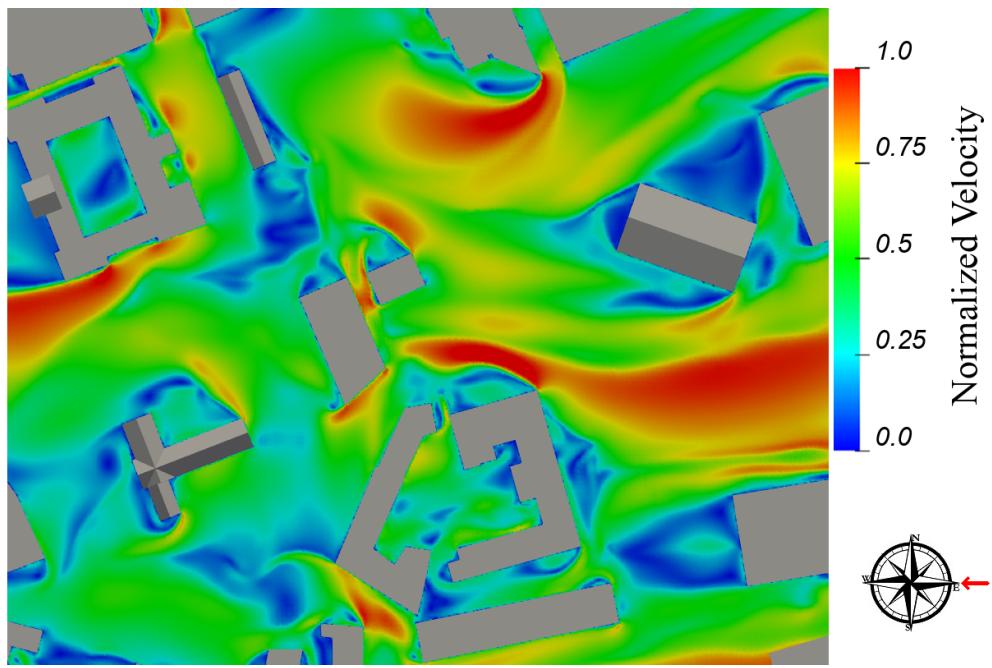


Figure 7.4: Ground Floor Level - Flow Velocity Results at  $Z=1.5\text{m}$  above the ground - Wind Direction:  $90^\circ$

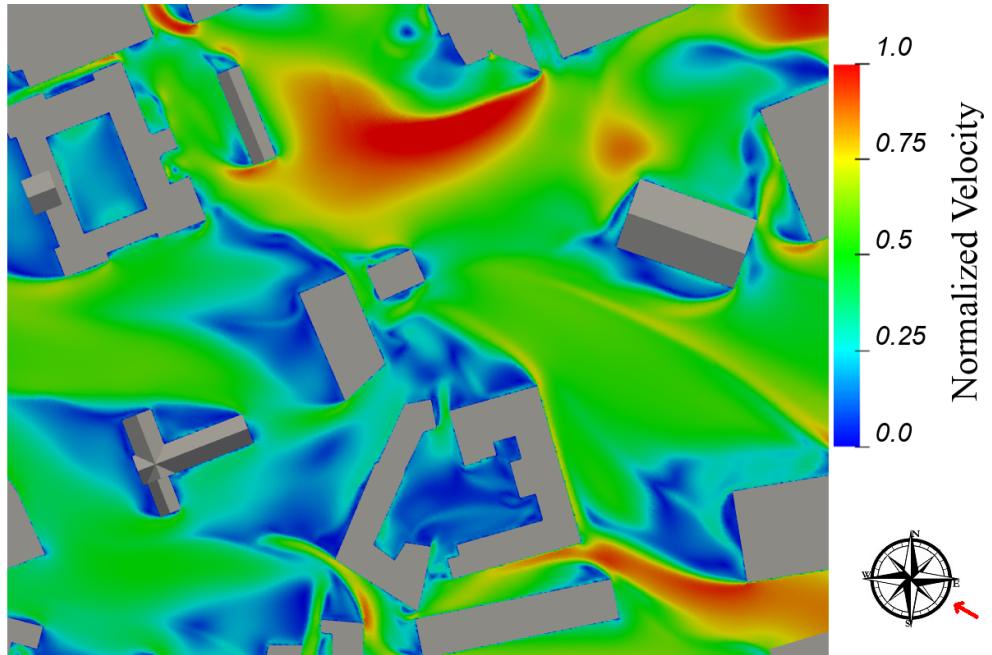


Figure 7.5: Ground Floor Level - Flow Velocity Results at  $Z=1.5\text{m}$  above the ground - Wind Direction:  $120^\circ$

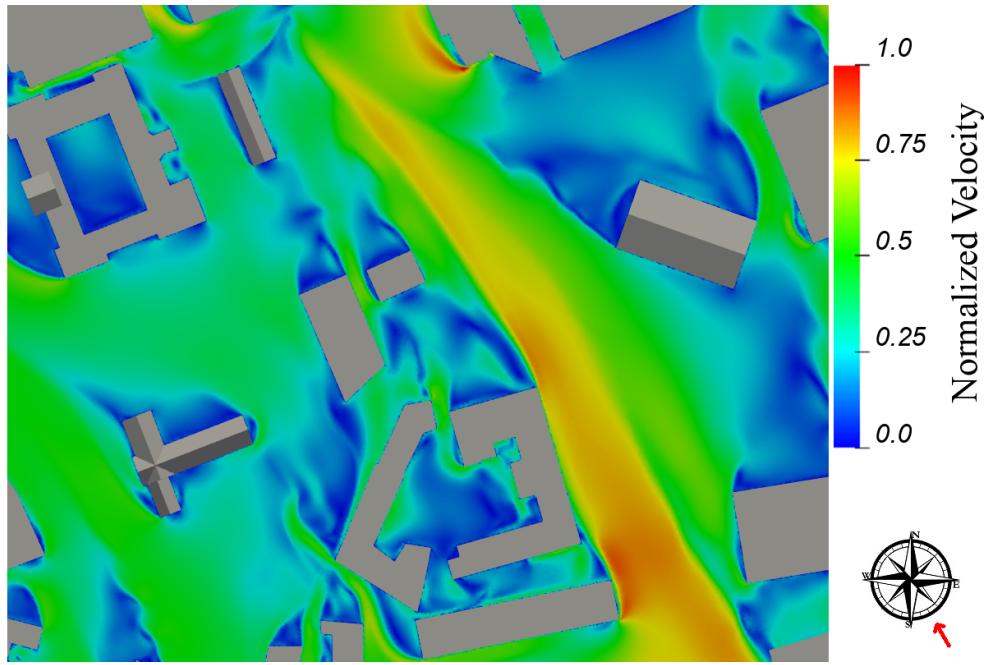


Figure 7.6: Ground Floor Level - Flow Velocity Results at  $Z=1.5m$  above the ground - Wind Direction:  $150^\circ$

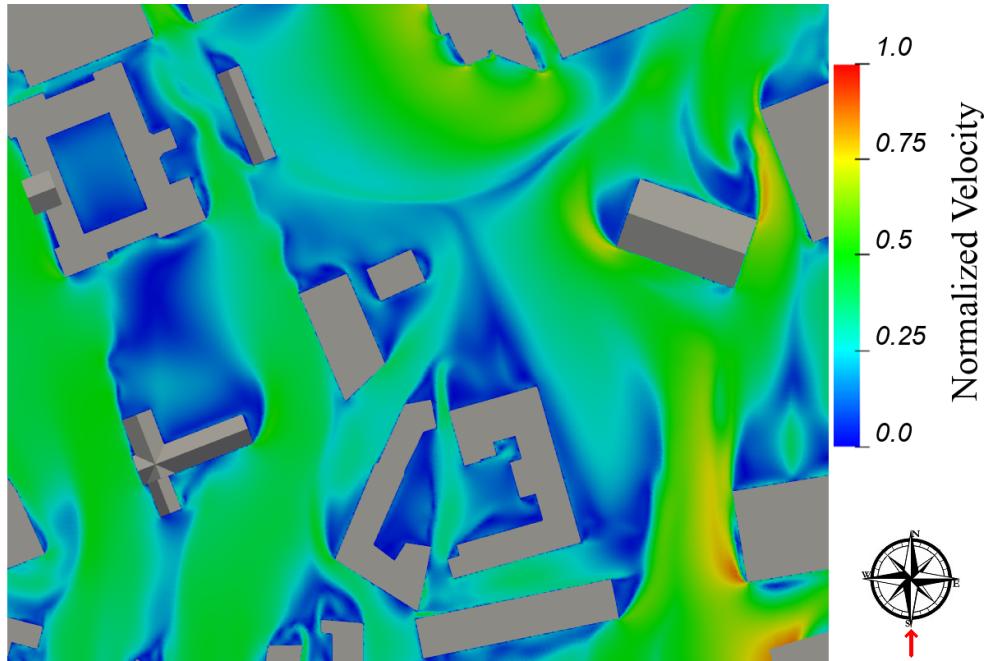


Figure 7.7: Ground Floor Level - Flow Velocity Results at  $Z=1.5m$  above the ground - Wind Direction:  $180^\circ$

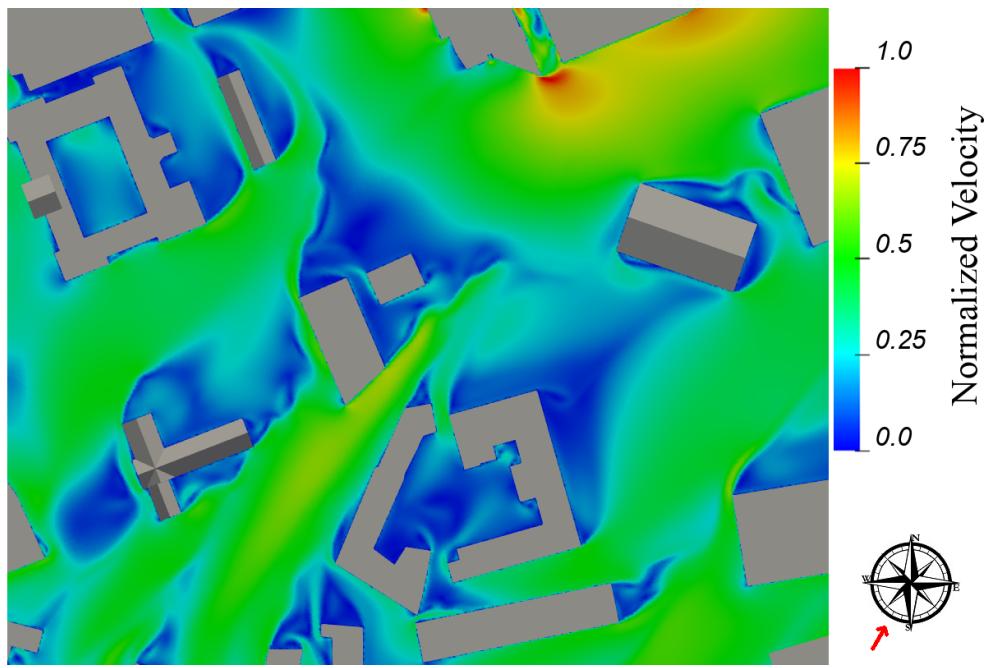


Figure 7.8: Ground Floor Level - Flow Velocity Results at  $Z=1.5\text{m}$  above the ground - Wind Direction:  $210^\circ$

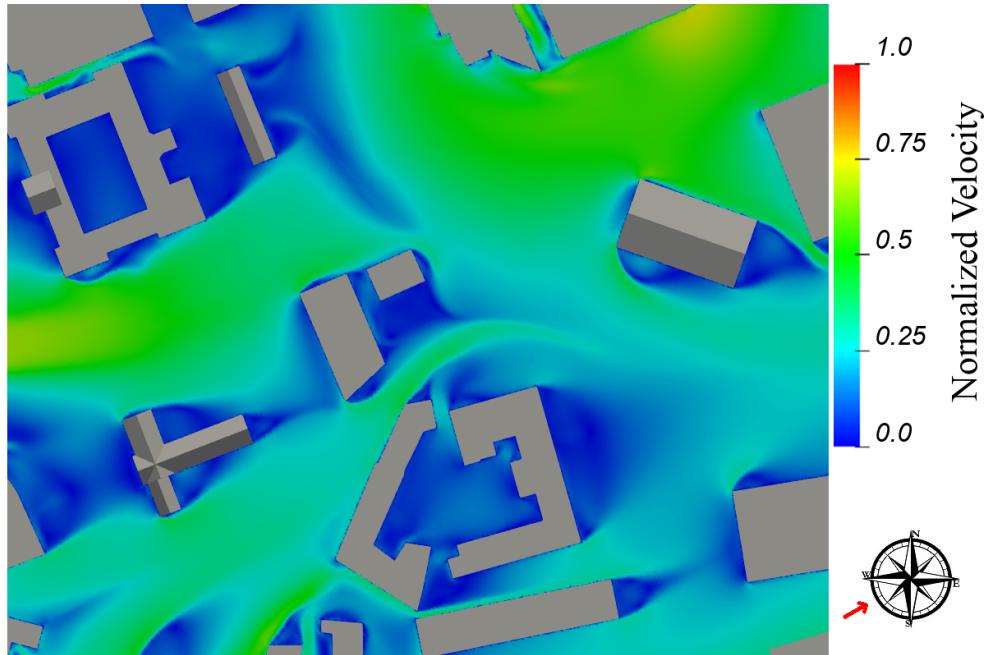


Figure 7.9: Ground Floor Level - Flow Velocity Results at  $Z=1.5\text{m}$  above the ground - Wind Direction:  $240^\circ$

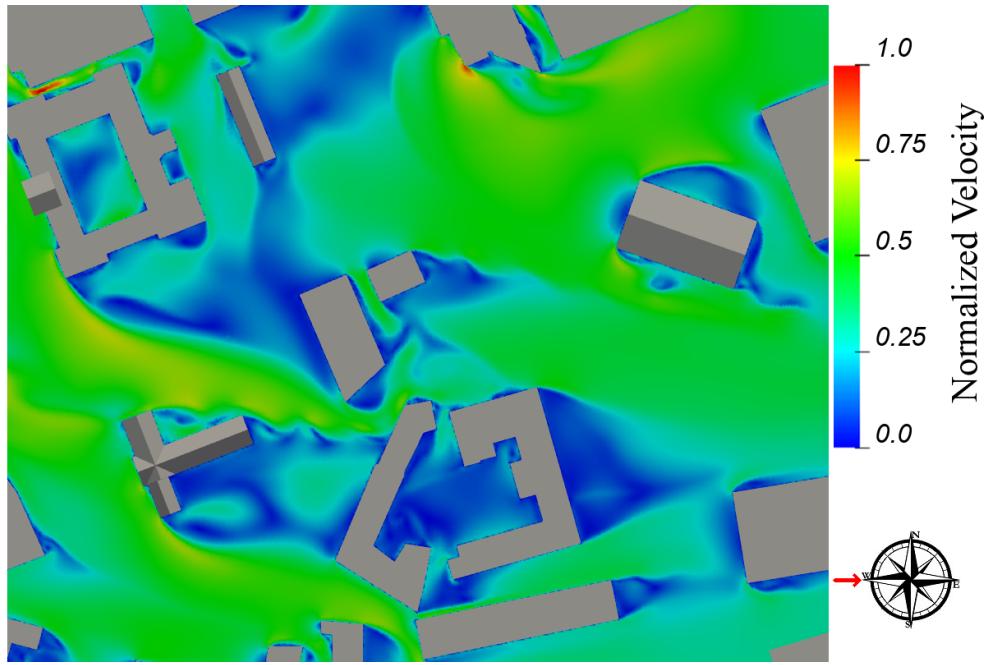


Figure 7.10: Ground Floor Level - Flow Velocity Results at  $Z=1.5\text{m}$  above the ground - Wind Direction:  $270^\circ$

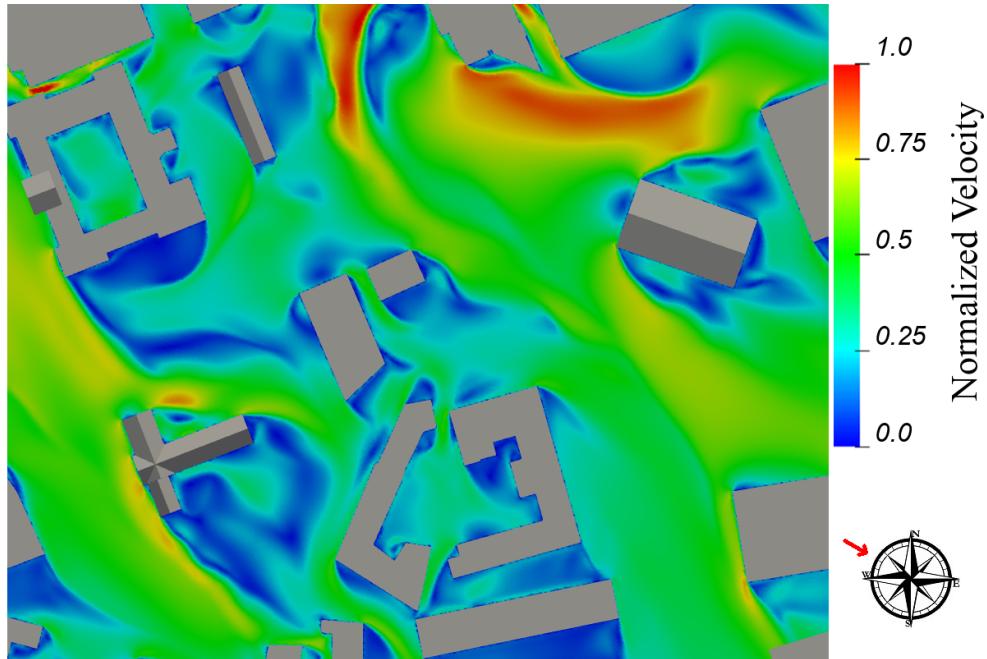


Figure 7.11: Ground Floor Level - Flow Velocity Results at  $Z=1.5\text{m}$  above the ground - Wind Direction:  $300^\circ$

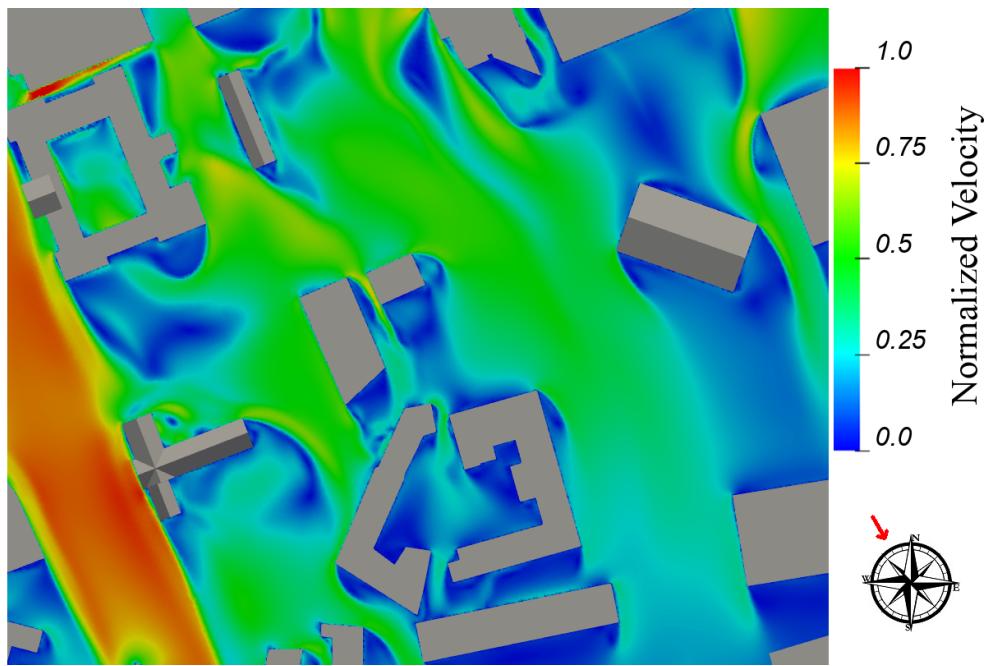


Figure 7.12: Ground Floor Level - Flow Velocity Results at  $Z=1.5\text{m}$  above the ground - Wind Direction:  $330^\circ$

### 7.1.2 BASELINE WIND MICROCLIMATE - Lawson Criteria

The wind flow results obtained simulating the different direction and wind speeds, are combined with wind frequencies of occurrence to obtain comfort ratings at pedestrian level in all areas included within the model. The comparison of comfort ratings with intended pedestrian activities is shown in the Lawson Comfort and Distress Map that follows. The comfort/distress conditions are presented in Figure 7.13 using a colour coded diagram formulated in accordance with the Lawson Criteria.

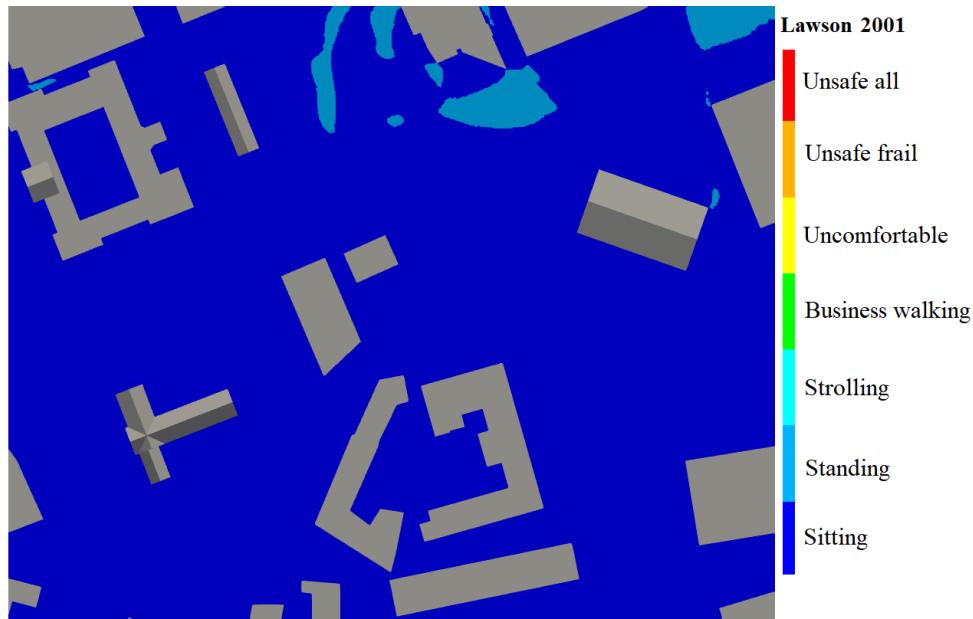


Figure 7.13: Ground Floor - Lawson Discomfort Map - Top View

From the simulation results the following observations are pointed out:

- The assessment of the baseline scenario has shown that no area is unsafe and no conditions of distress are created in the existing environment under the local wind climate.
- The site is usable for sitting/standing, the roads in the surrounding are usable for their intended scope.

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## **8. IMPACT OF THE PROPOSED DEVELOPMENT**

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This section assessed the potential impact of the proposed development on the already existing environment, and the suitability of the proposed development to create and maintain a suitable and comfortable environment for different pedestrian activities.

## **8.1 CONSTRUCTION PHASE**

As the finalization of the development proceeds, the wind setting at the site would progressively conform to those of the completed development. Due to the fact that windier conditions are acceptable within a construction area (not accessible to the public), and the proposed development would not be the reason for critical wind conditions on-Site (and are slightly calmer when the development is in site), the impacts evaluated on-Site are considered to be insignificant. Thus, the predicted impacts during construction phase are identified as not significant or negligible.

In summary, as construction of Anglesea Terrace Residential Development progresses, the wind conditions at the site would gradually adjust to those of the completed development. During the construction phase, predicted impacts are classified as negligible.

## **8.2 OPERATIONAL PHASE**

This section shows CFD results of wind microclimate assessment carried out considering the "Operational Phase" of Anglesea Terrace Residential Development. In this case the assessment has considered the impact of wind on the existing area including Anglesea Terrace Residential Development. Wind simulations have been carried out on all the various directions for which the development could show critical areas in terms of pedestrian comfort and safety.

Results of wind microclimate at pedestrian level (1.5m height - flow speeds) are collected throughout the modelled site(potential receptors). These flow velocities identify if locally, wind speeds at pedestrian-level are accelerated or decelerated in relation to the undisturbed reference wind speed due to the presence of the existing baseline environment.

The impact of these speeds are then combined with their specific frequency of occurrence and presented in the maps that show the area of comfort and distress in accordance with Lawson Criteria, these maps are produced at pedestrian level on the ground or on the courtyards, and identify the suitability of each areas to its prescribed level of usage and activity.

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### 8.2.1 WIND SPEEDS - Pedestrian Level

Results of wind speeds and their circulations at pedestrian level of 1.5m above the potential receptors are presented in Figures 8.1 to 8.36 in order to assess wind flows at the ground floor level and terraces of Anglesea Terrace Residential Development.

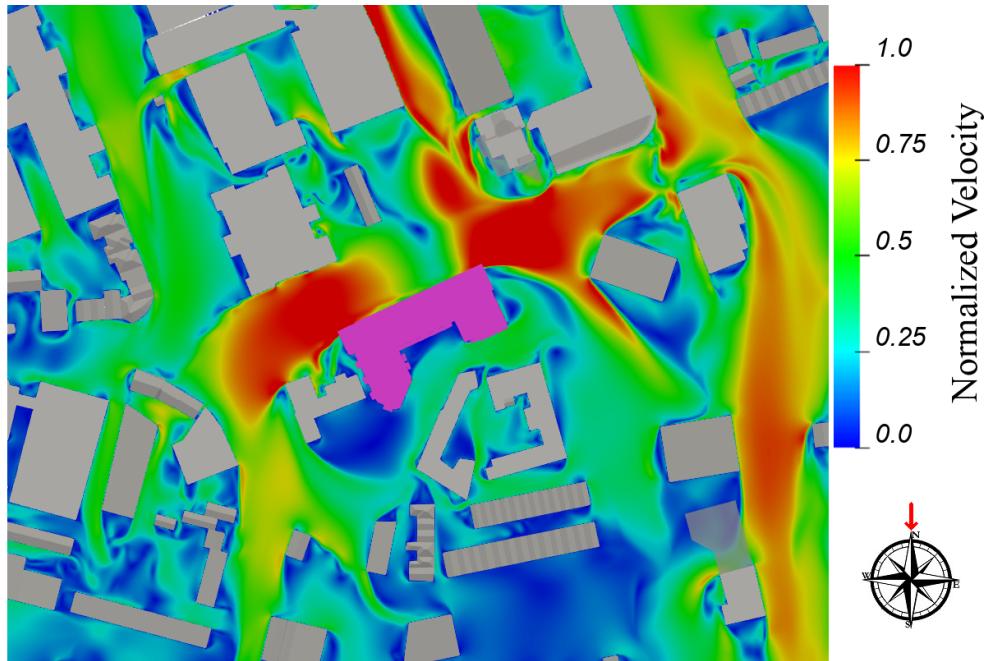


Figure 8.1: Flow Velocity Results at 1.5m above the ground - Wind Direction:  $0^\circ$

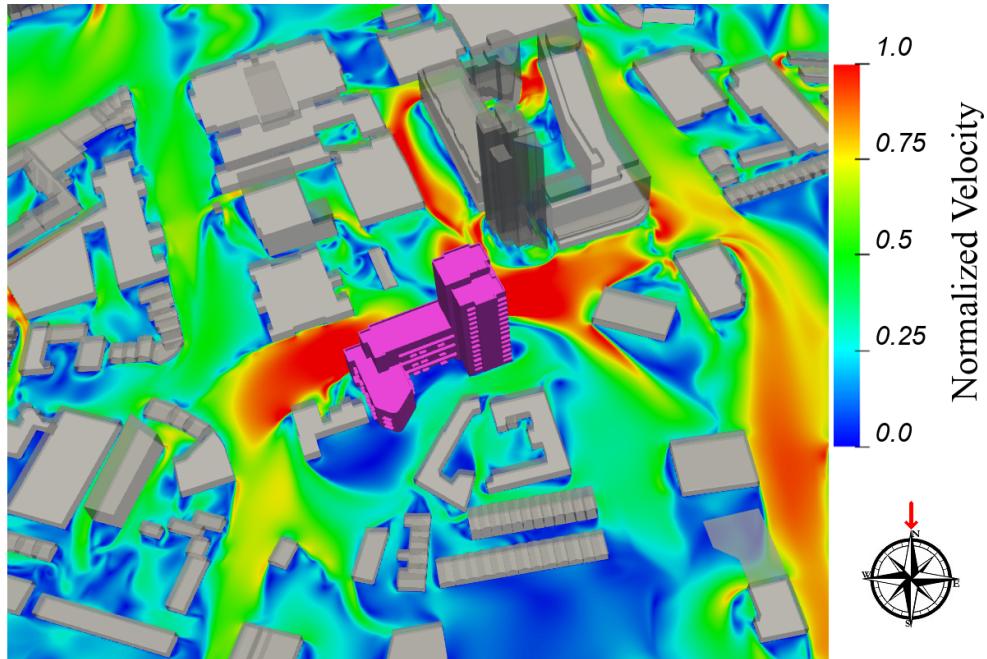


Figure 8.2: Flow Velocity Results at 1.5m above the ground - 3D - Wind Direction:  $0^\circ$

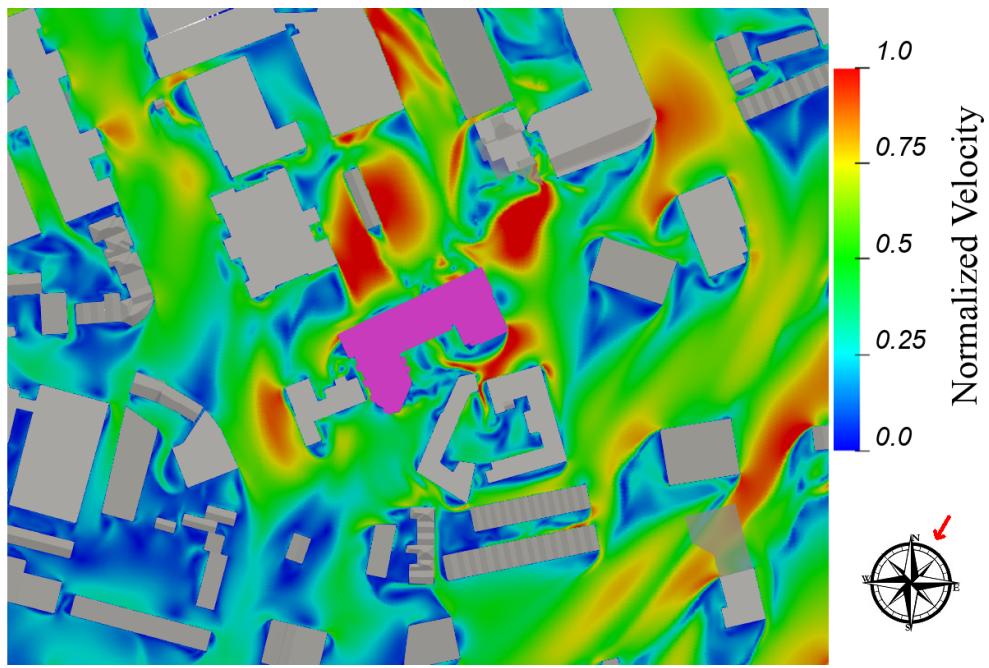


Figure 8.3: Flow Velocity Results at 1.5m above the ground - Wind Direction: 30°

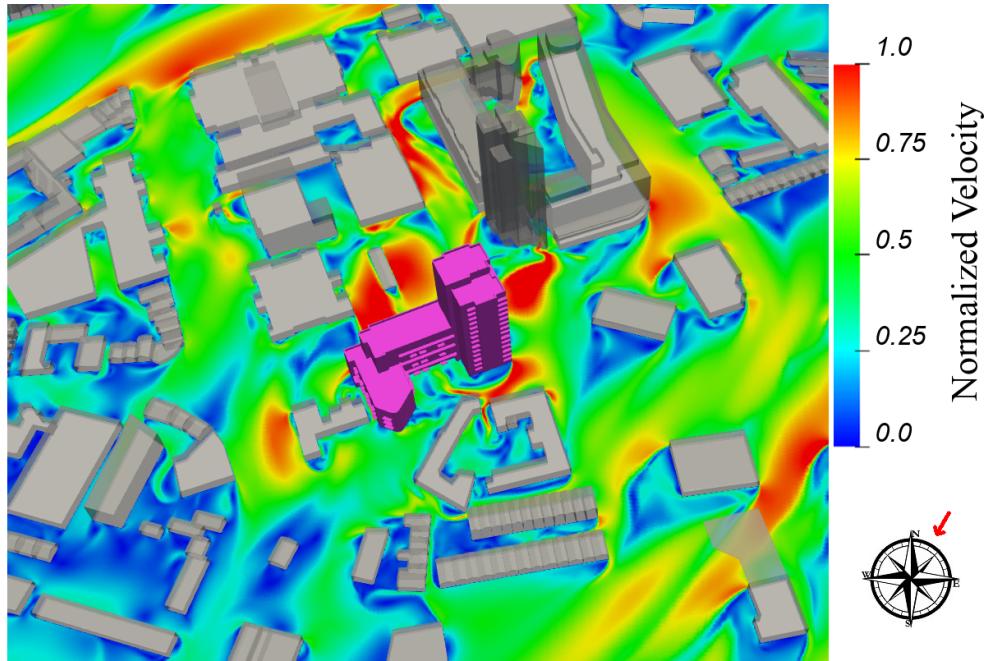


Figure 8.4: Flow Velocity Results at 1.5m above the ground - 3D - Wind Direction: 30°

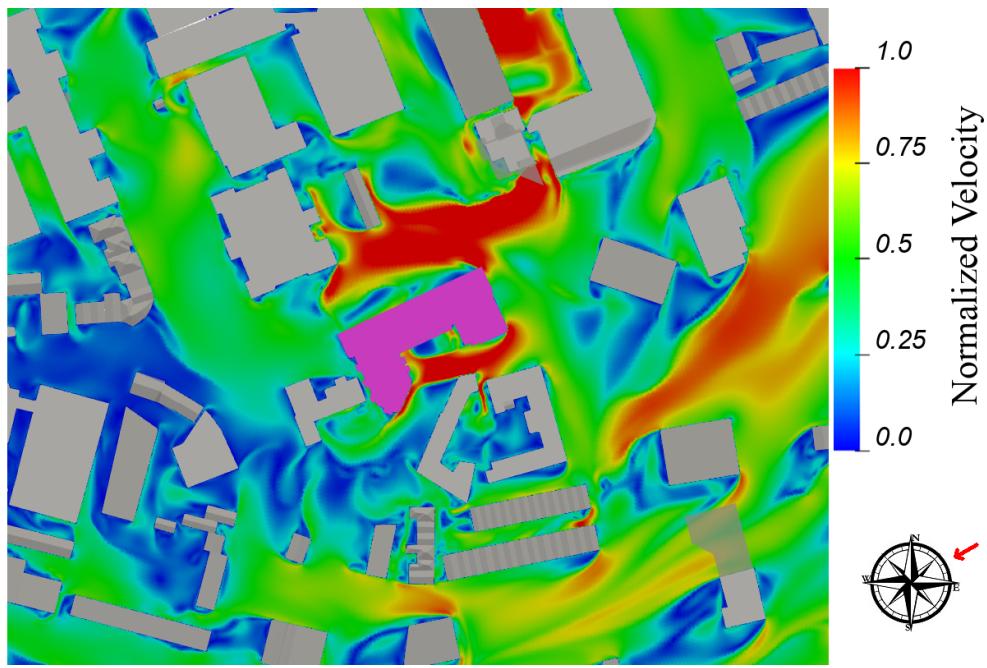


Figure 8.5: Flow Velocity Results at 1.5m above the ground - Wind Direction: 60°

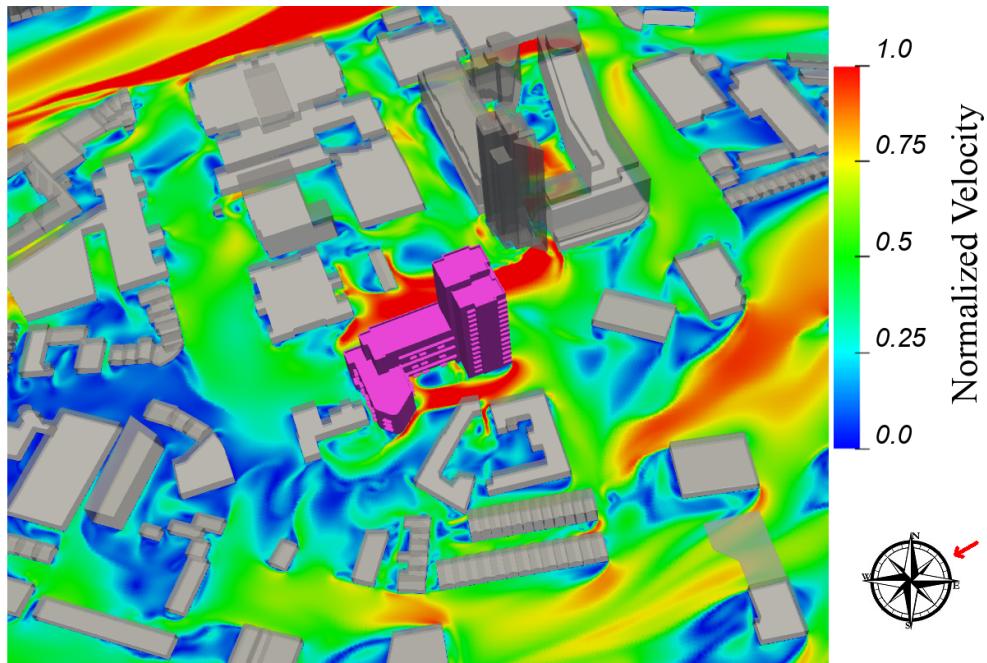


Figure 8.6: Flow Velocity Results at 1.5m above the ground - 3D - Wind Direction: 60°

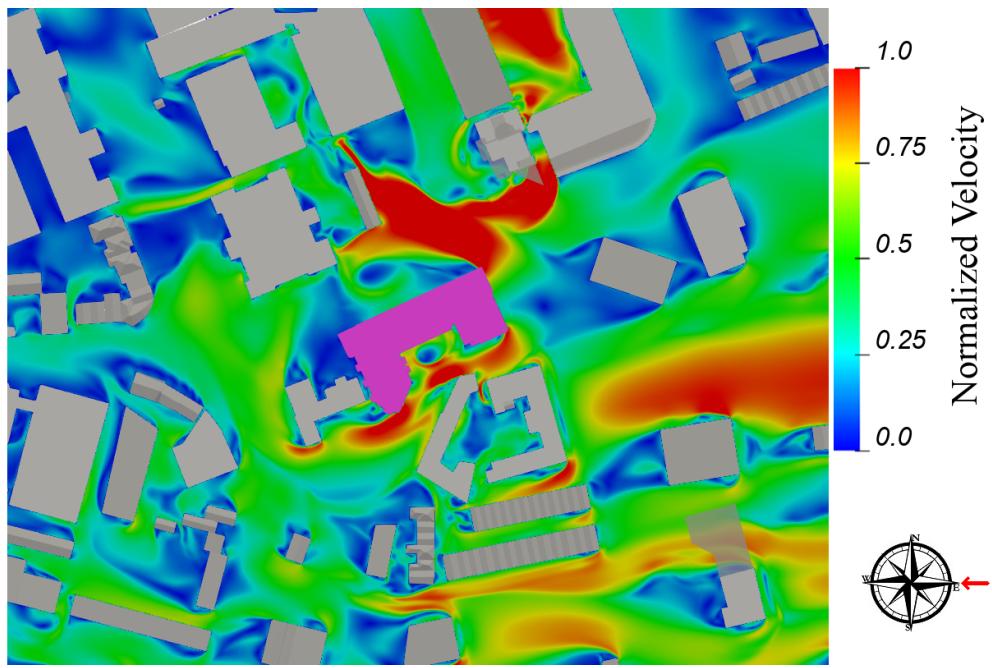


Figure 8.7: Flow Velocity Results at 1.5m above the ground - Wind Direction: 90°

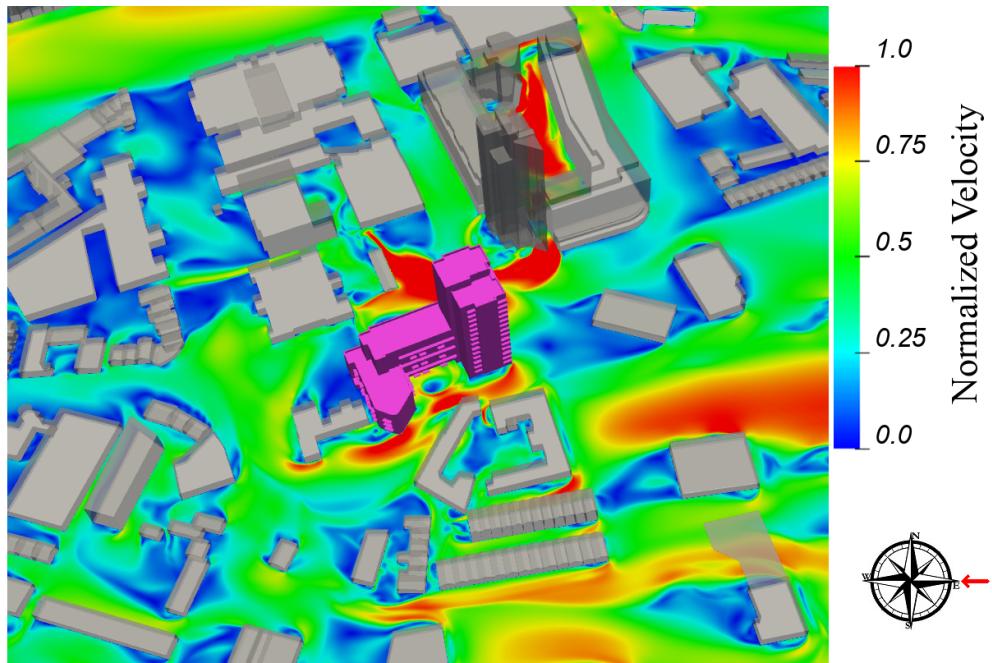


Figure 8.8: Flow Velocity Results at 1.5m above the ground - 3D - Wind Direction: 90°

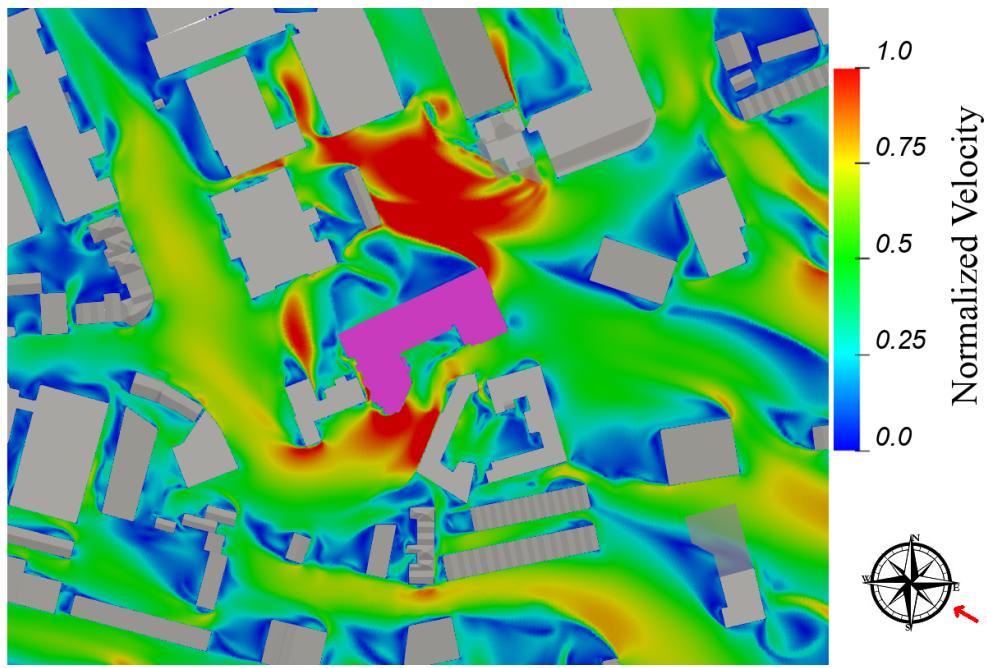


Figure 8.9: Flow Velocity Results at 1.5m above the ground - Wind Direction: 120°

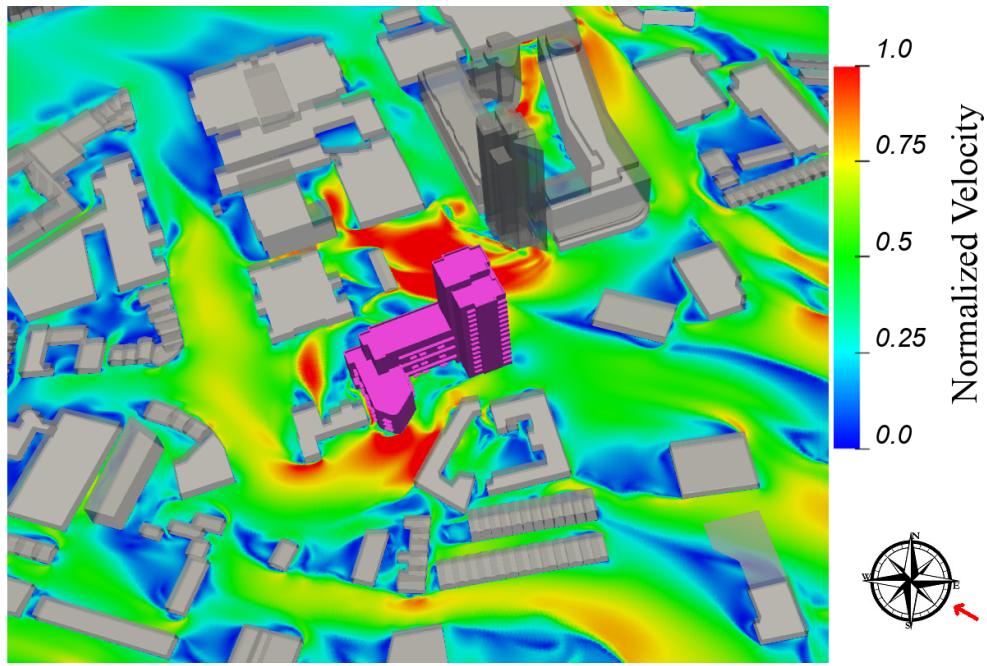


Figure 8.10: Flow Velocity Results at 1.5m above the ground - 3D - Wind Direction: 120°

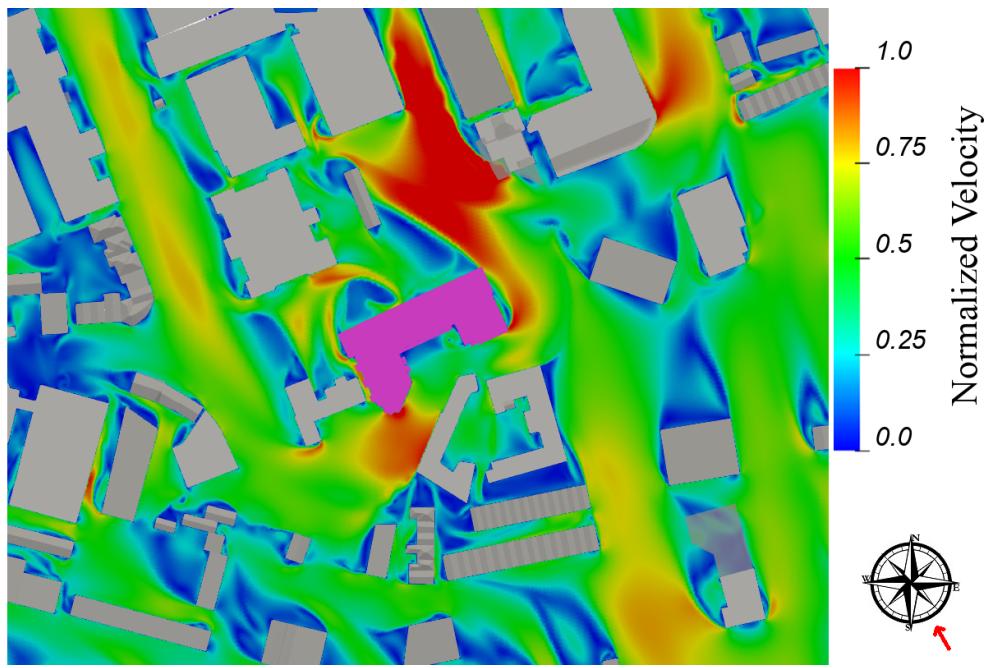


Figure 8.11: Flow Velocity Results at 1.5m above the ground - Wind Direction: 150°

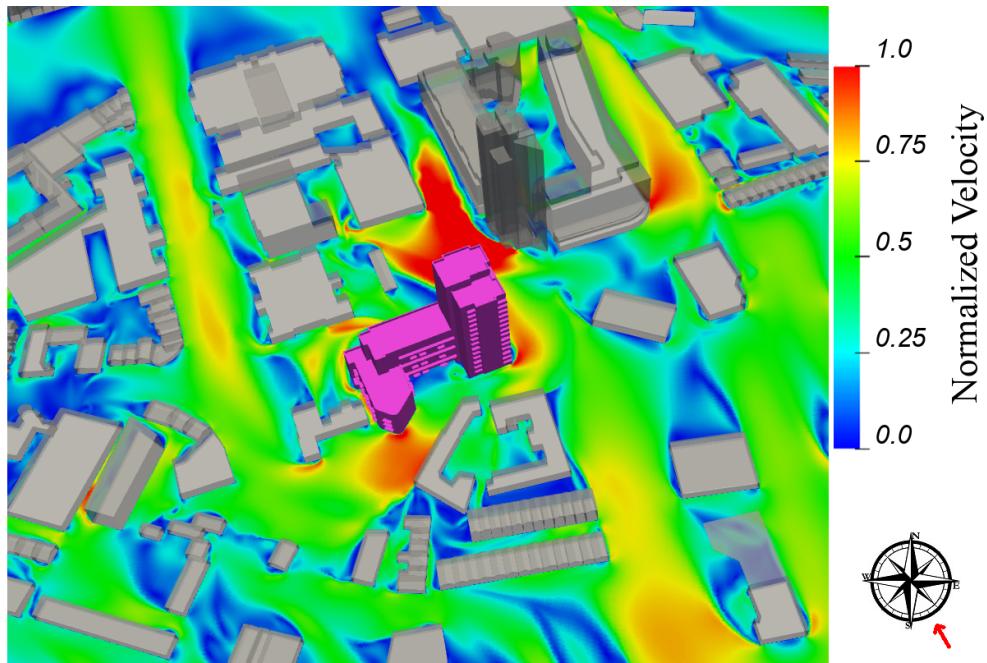


Figure 8.12: Flow Velocity Results at 1.5m above the ground - 3D - Wind Direction: 150°

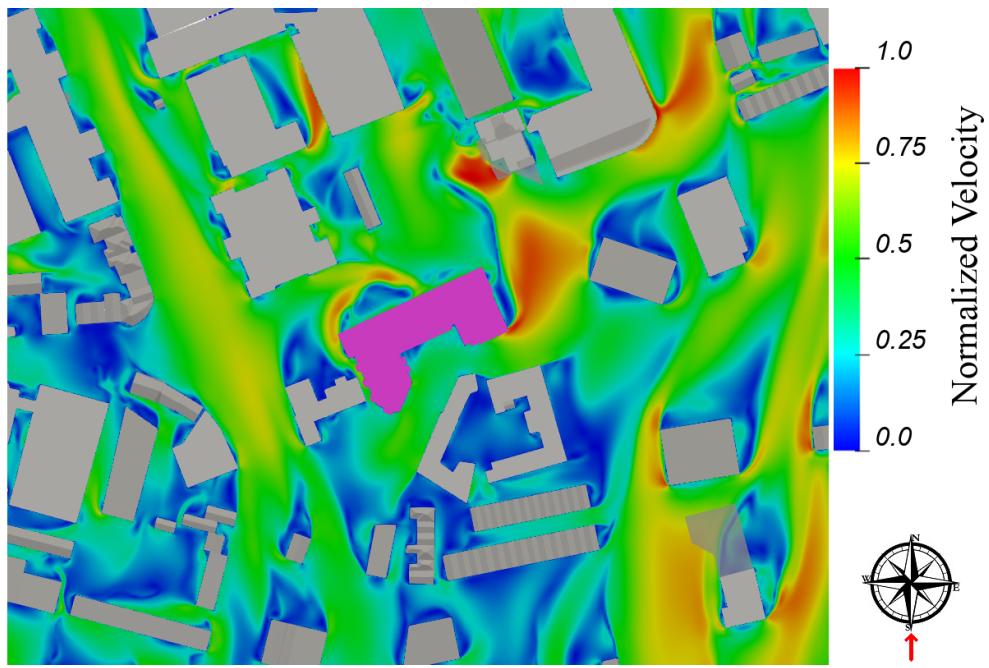


Figure 8.13: Flow Velocity Results at 1.5m above the ground - Wind Direction: 180°

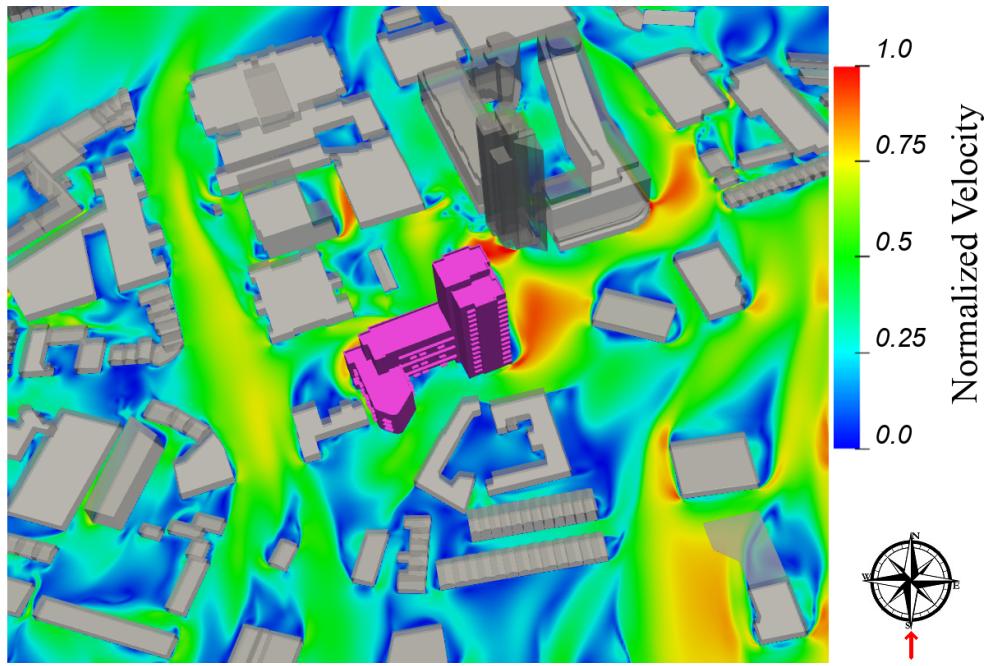


Figure 8.14: Flow Velocity Results at 1.5m above the ground - 3D - Wind Direction: 180°

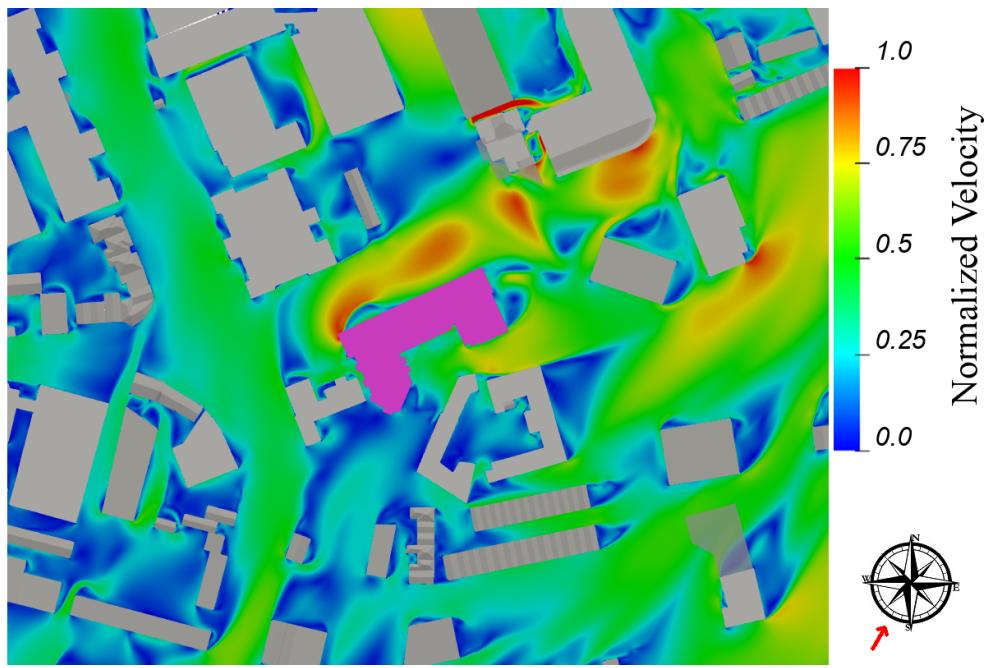


Figure 8.15: Flow Velocity Results at 1.5m above the ground - Wind Direction: 210°

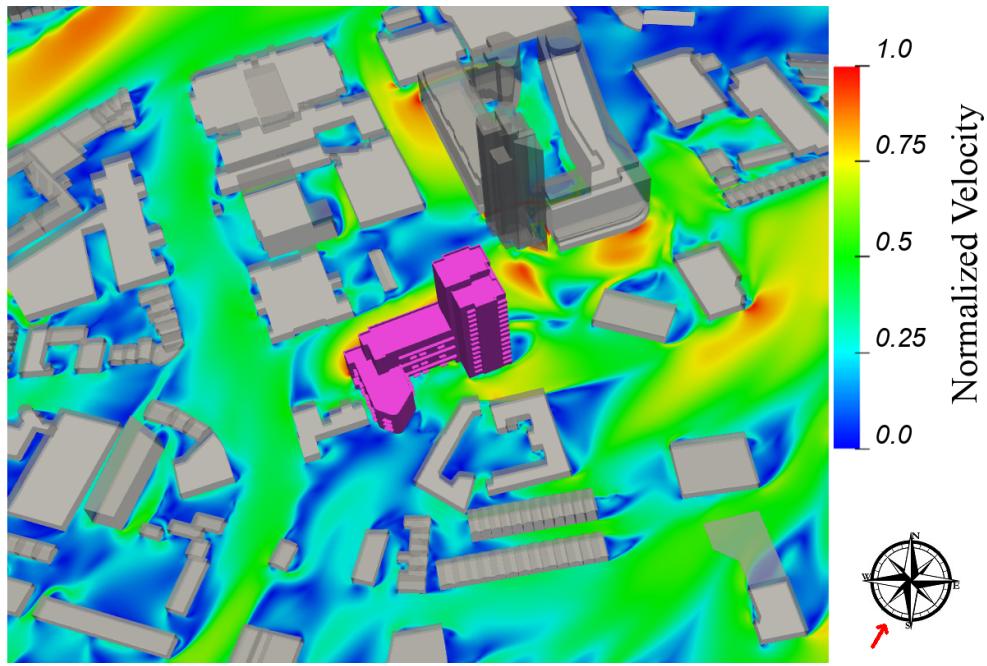


Figure 8.16: Flow Velocity Results at 1.5m above the ground - 3D - Wind Direction: 210°

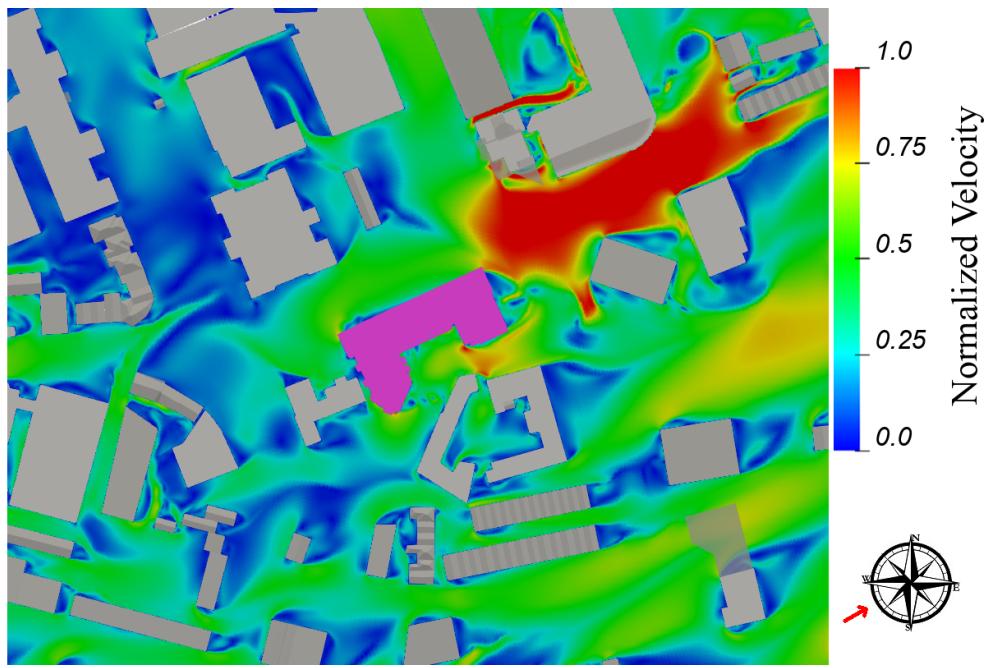


Figure 8.17: Flow Velocity Results at 1.5m above the ground - Wind Direction: 240°

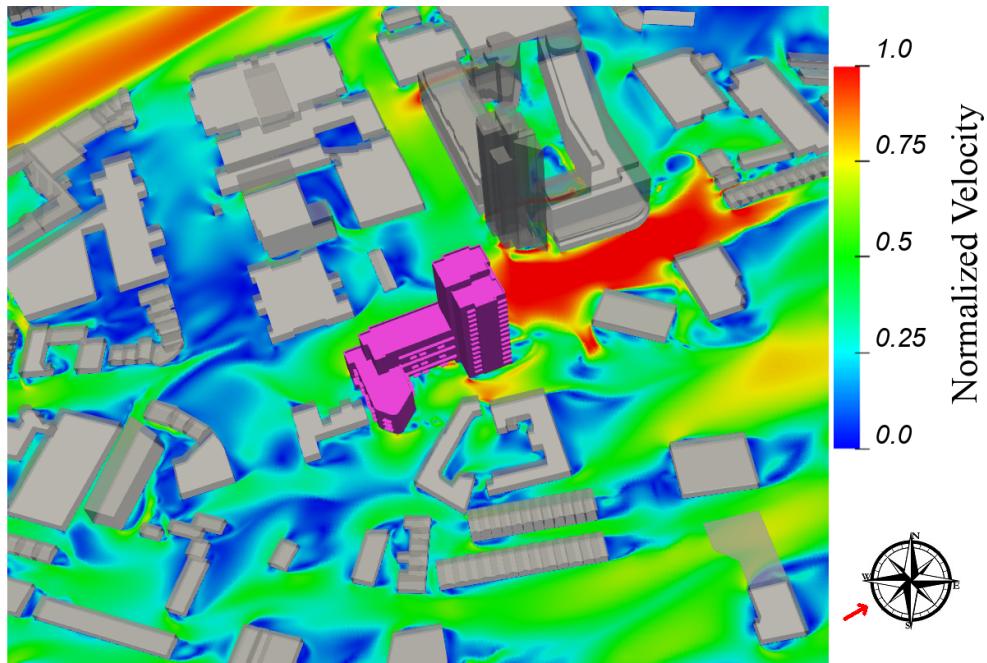


Figure 8.18: Flow Velocity Results at 1.5m above the ground - 3D - Wind Direction: 240°

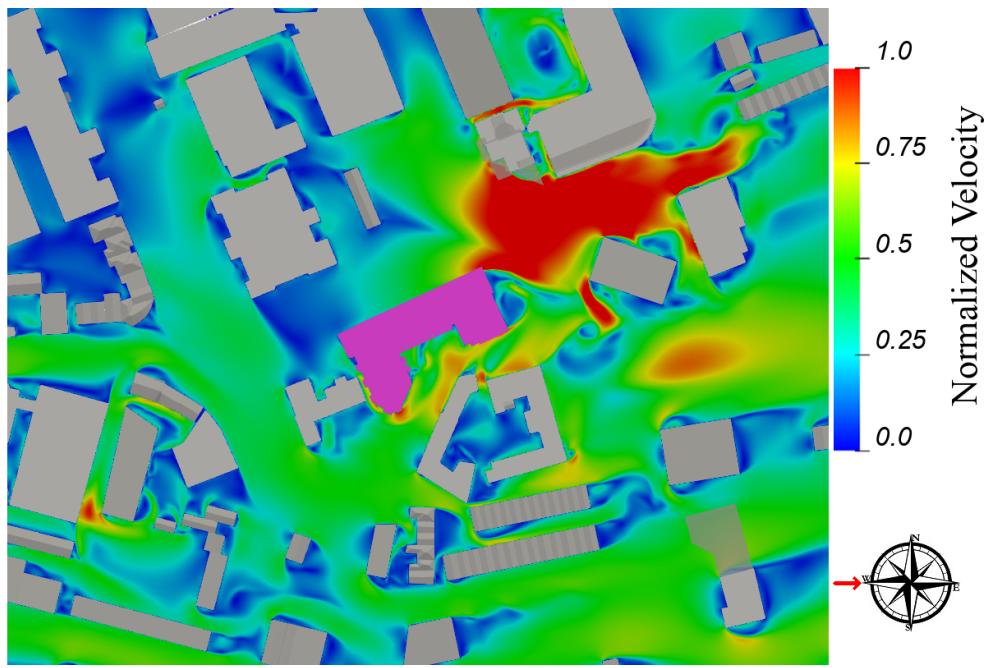


Figure 8.19: Flow Velocity Results at 1.5m above the ground - Wind Direction: 270°

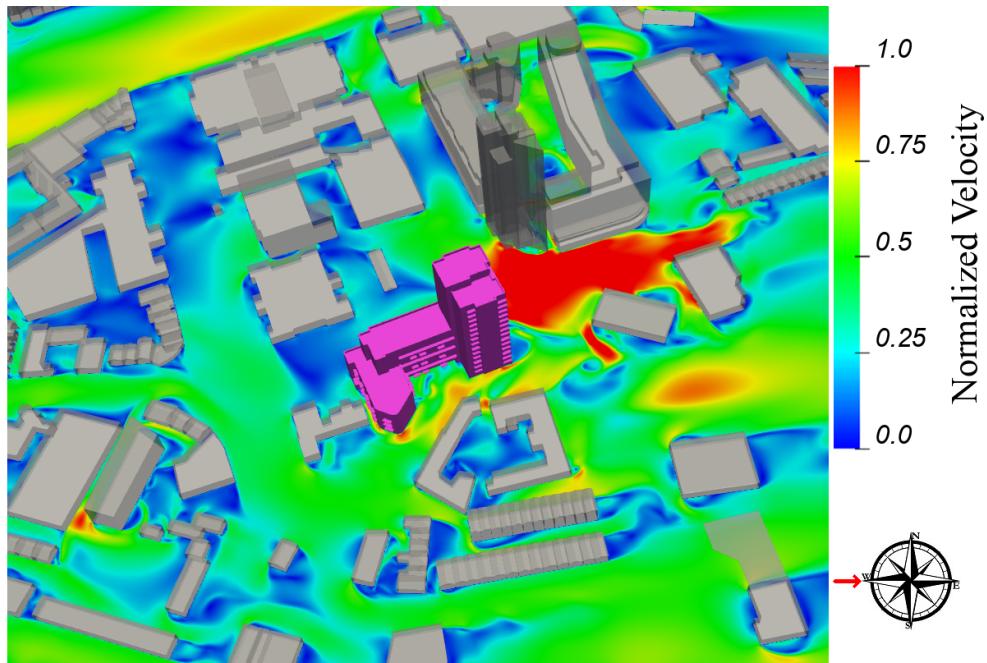


Figure 8.20: Flow Velocity Results at 1.5m above the ground - 3D - Wind Direction: 270°

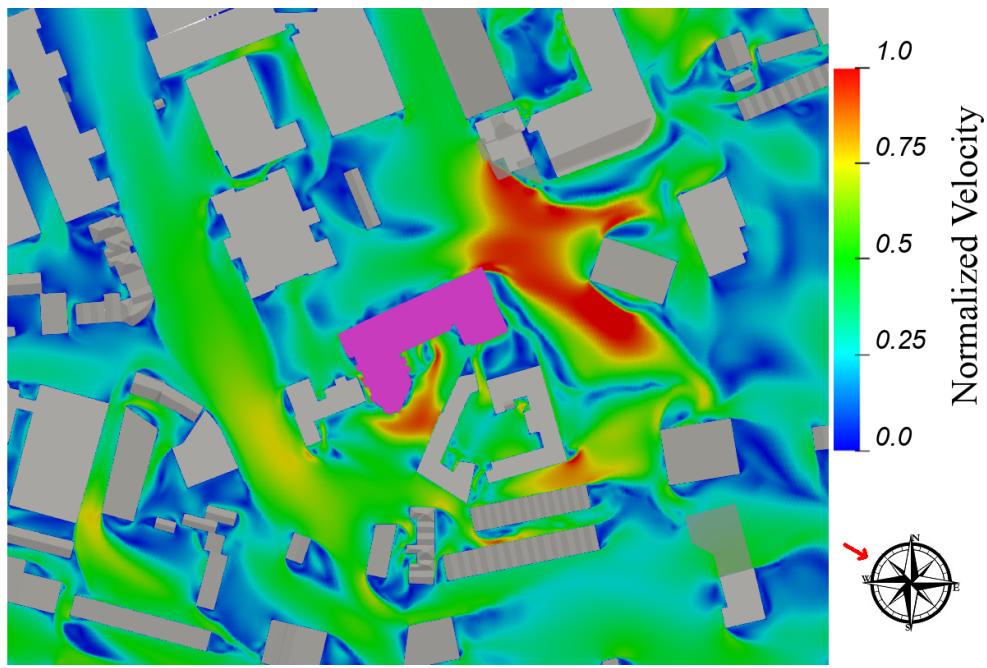


Figure 8.21: Flow Velocity Results at 1.5m above the ground - Wind Direction: 300°

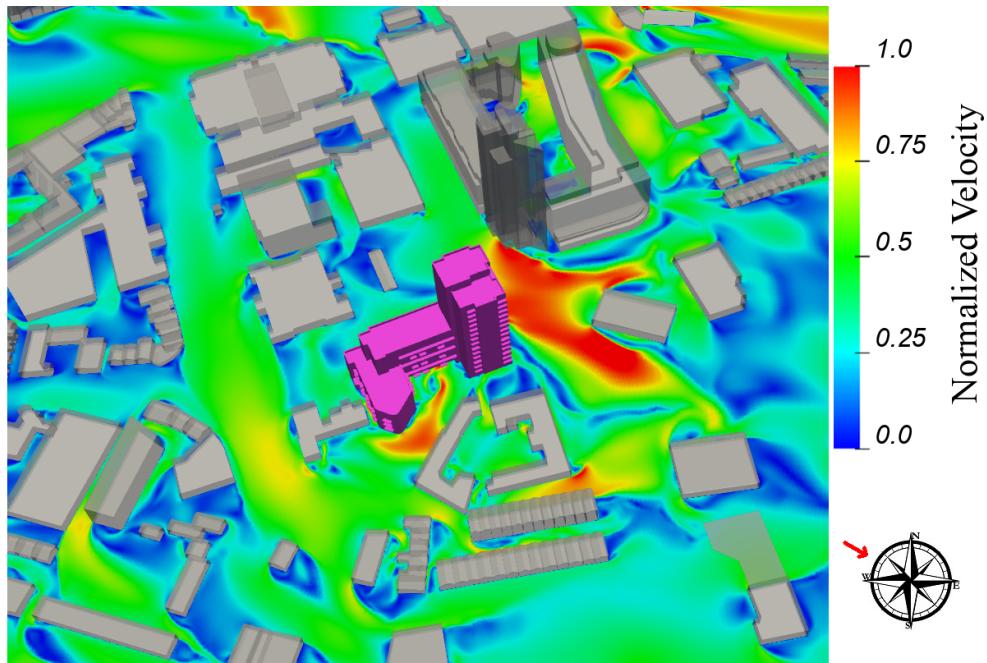


Figure 8.22: Flow Velocity Results at 1.5m above the ground - 3D - Wind Direction: 300°

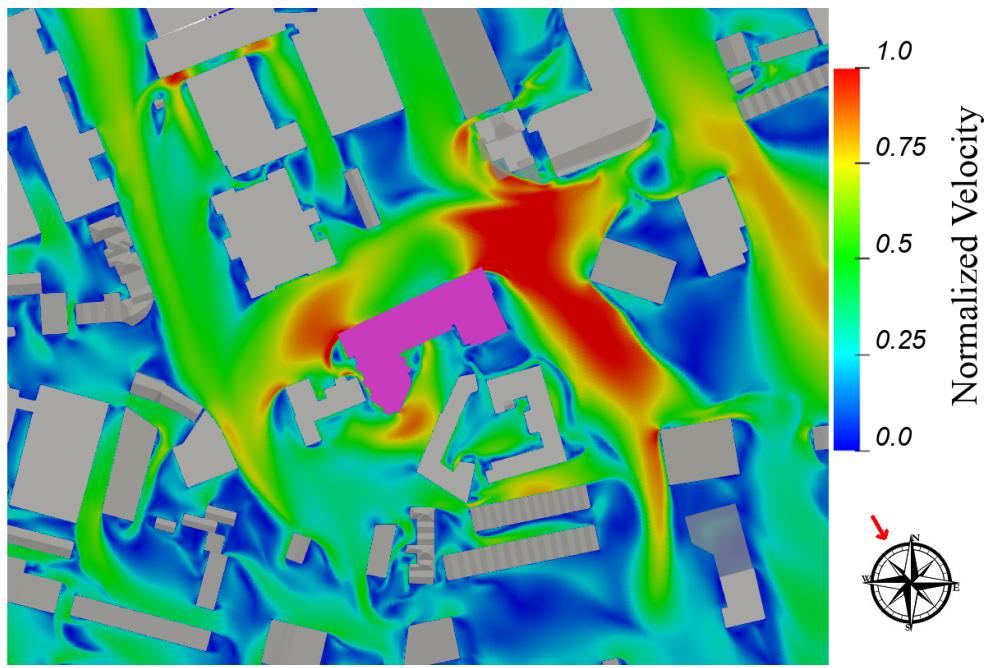


Figure 8.23: Flow Velocity Results at 1.5m above the ground - Wind Direction: 330°

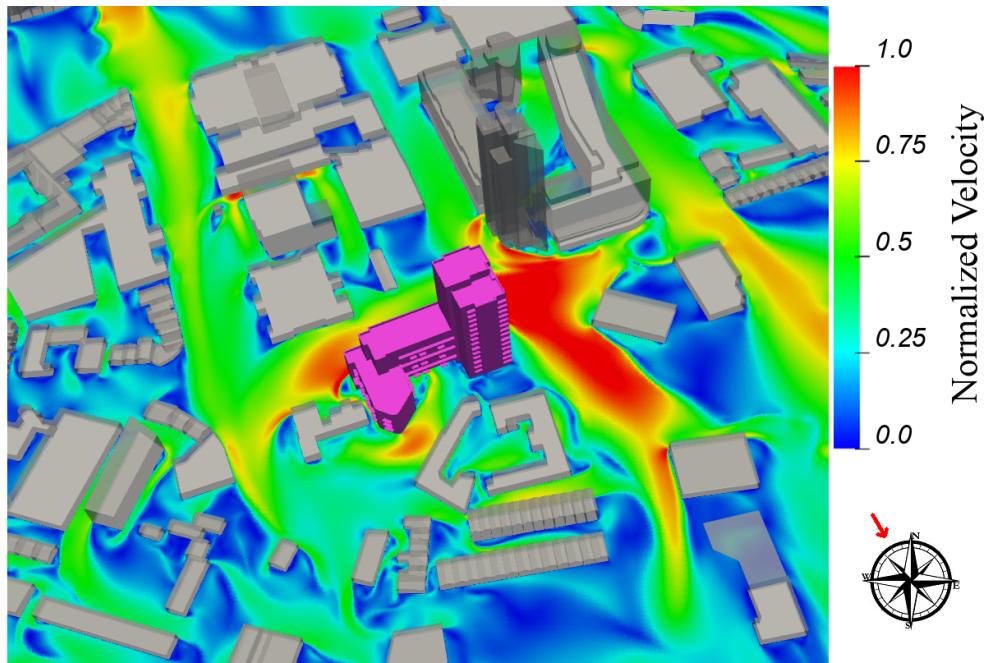


Figure 8.24: Flow Velocity Results at 1.5m above the ground - 3D - Wind Direction: 330°

### 8.2.2 Rooftops

Results of wind speeds and their circulations at Rooftop 4 and Rooftop 7 are presented in Figures 8.25 to 8.36 in order to assess wind flows at the terraces of Anglesea Terrace Residential Development.

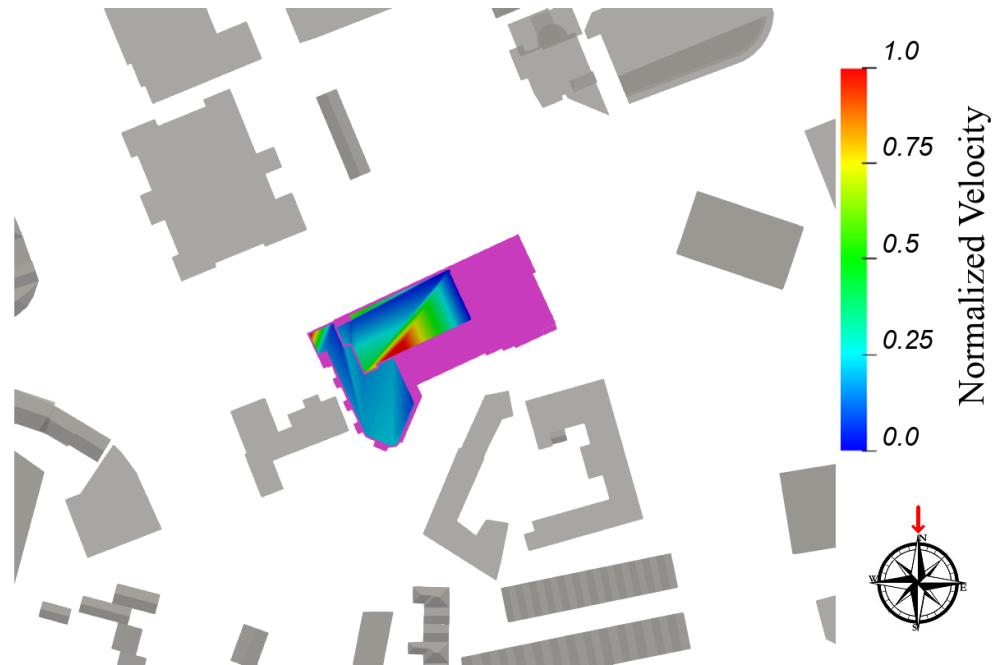


Figure 8.25: Flow Velocity Results at 1.5m above the roof terraces - Wind Direction: 0°



Figure 8.26: Flow Velocity Results at 1.5m above the roof terraces - Wind Direction: 30°

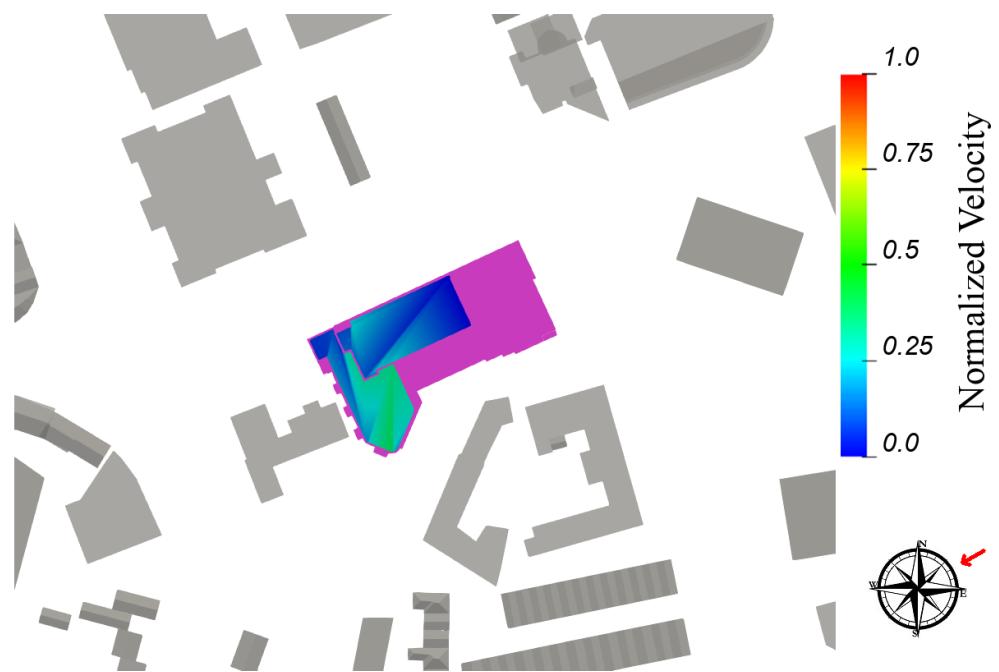


Figure 8.27: Flow Velocity Results at 1.5m above the roof terraces - Wind Direction: 60°

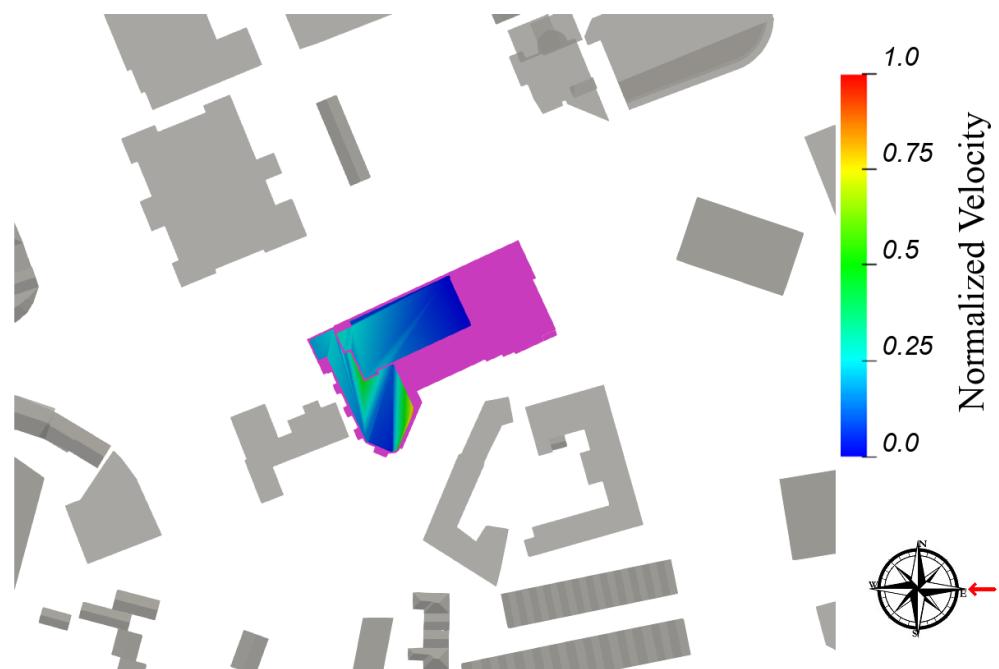


Figure 8.28: Flow Velocity Results at 1.5m above the roof terraces - Wind Direction: 90°

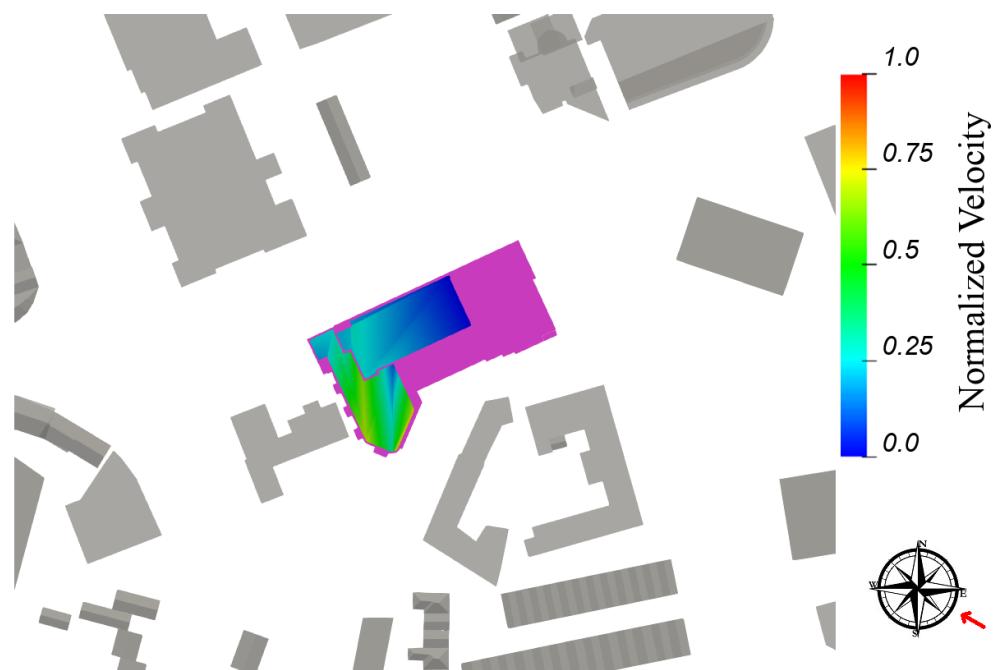


Figure 8.29: Flow Velocity Results at 1.5m above the roof terraces - Wind Direction: 120°

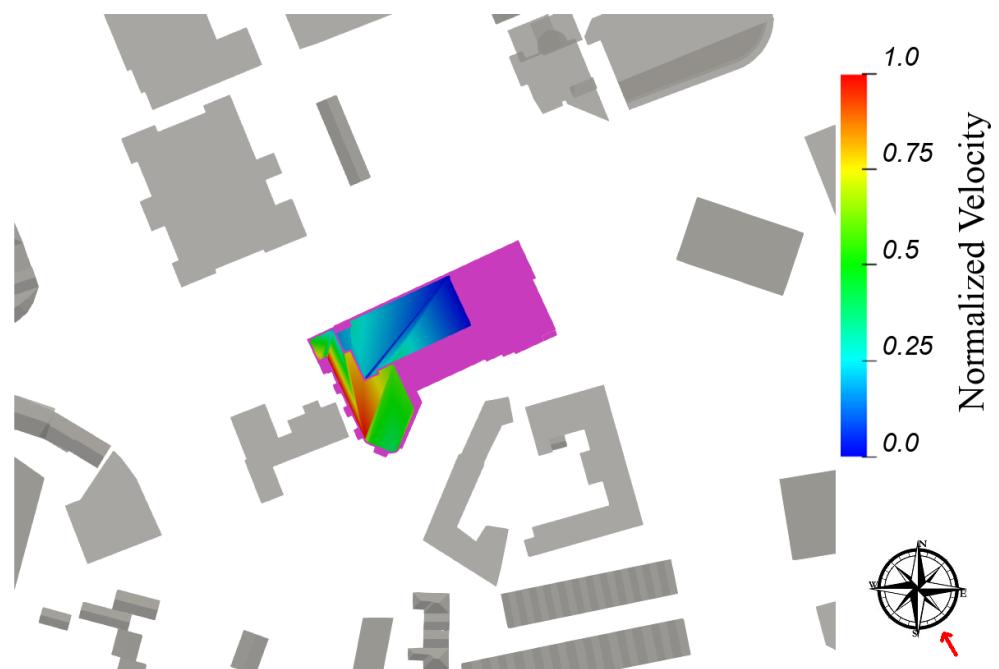


Figure 8.30: Flow Velocity Results at 1.5m above the roof terraces - Wind Direction: 150°

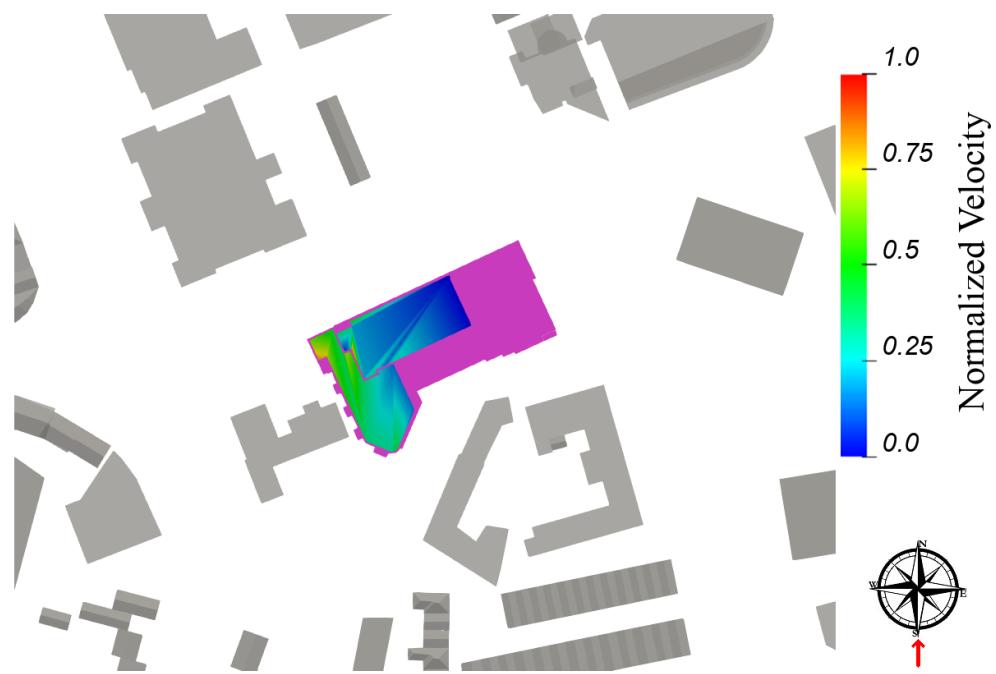


Figure 8.31: Flow Velocity Results at 1.5m above the roof terraces - Wind Direction: 180°

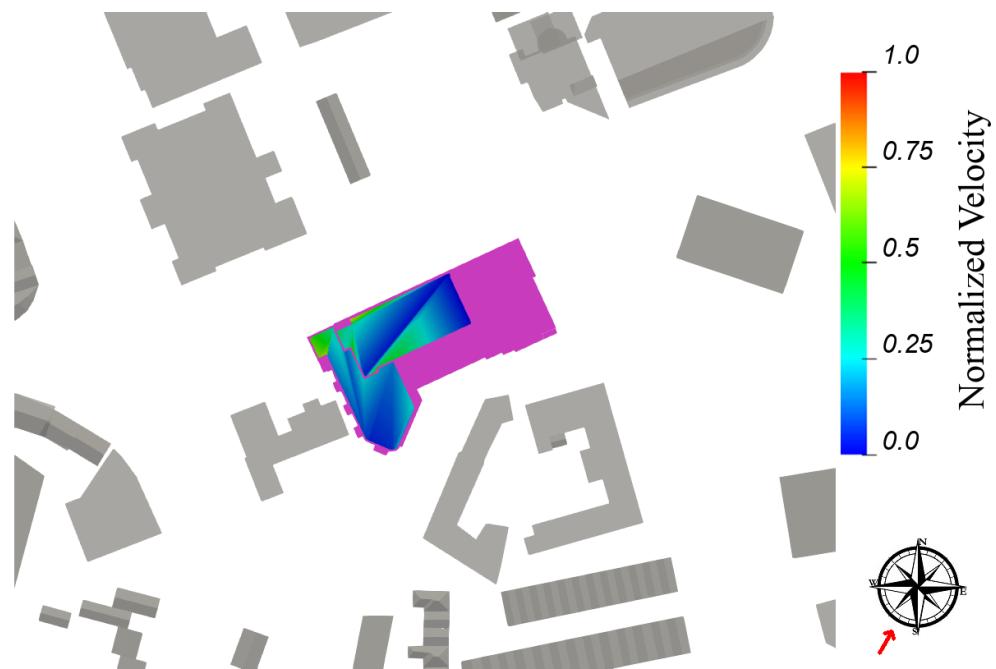


Figure 8.32: Flow Velocity Results at 1.5m above the roof terraces - Wind Direction: 210°

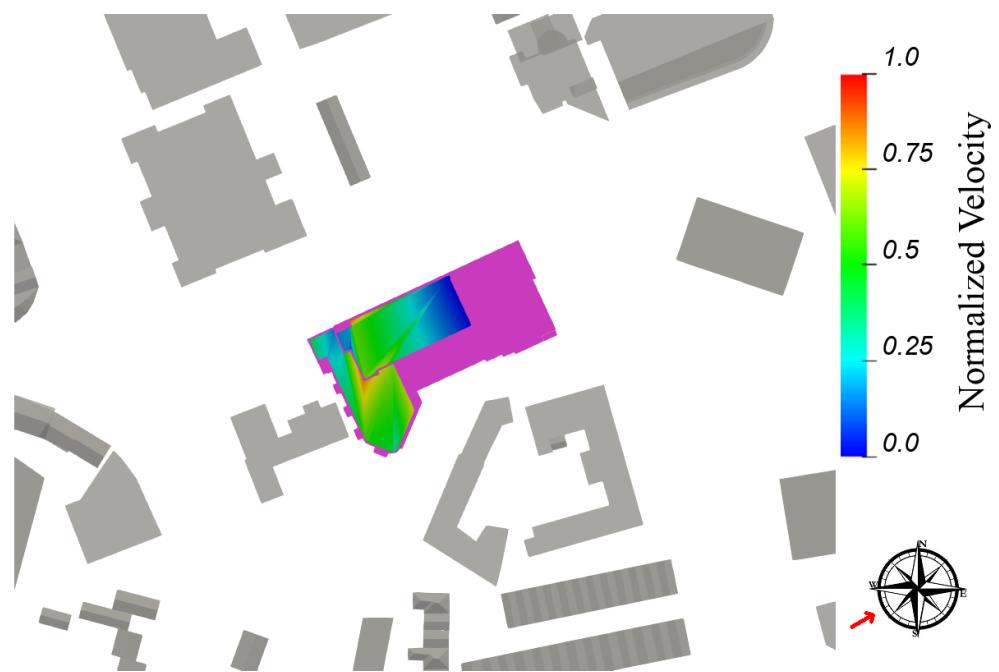


Figure 8.33: Flow Velocity Results at 1.5m above the roof terraces - Wind Direction: 240°

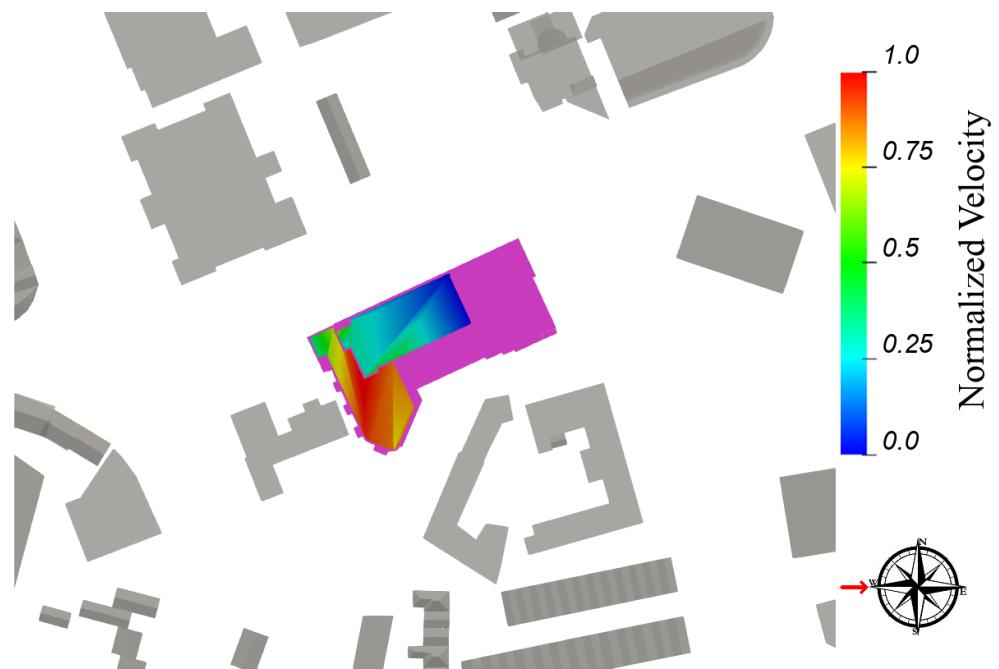


Figure 8.34: Flow Velocity Results at 1.5m above the roof terraces - Wind Direction: 270°

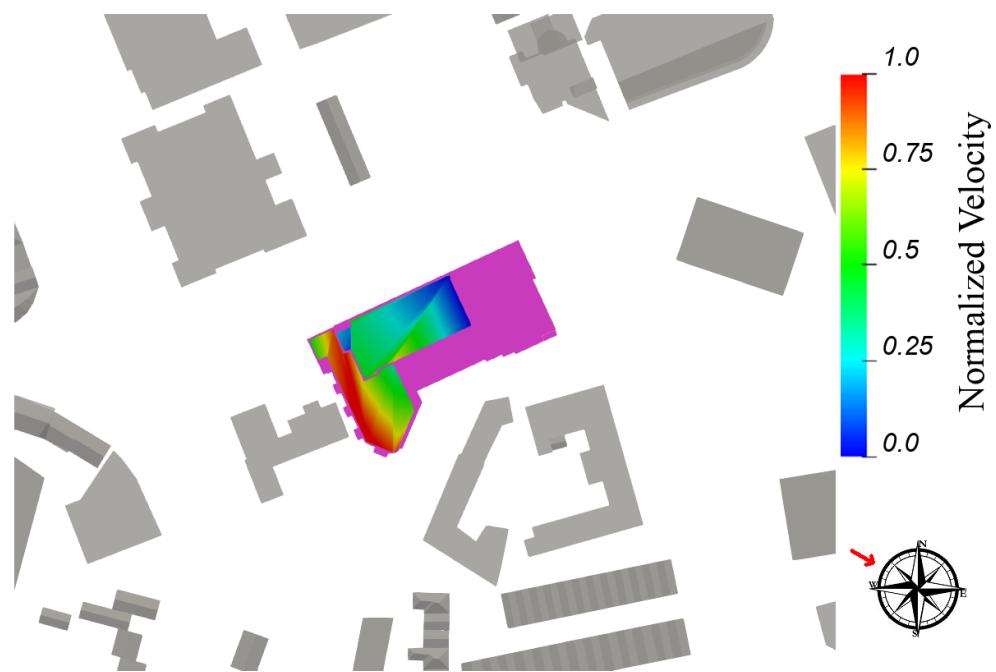


Figure 8.35: Flow Velocity Results at 1.5m above the roof terraces - Wind Direction: 300°

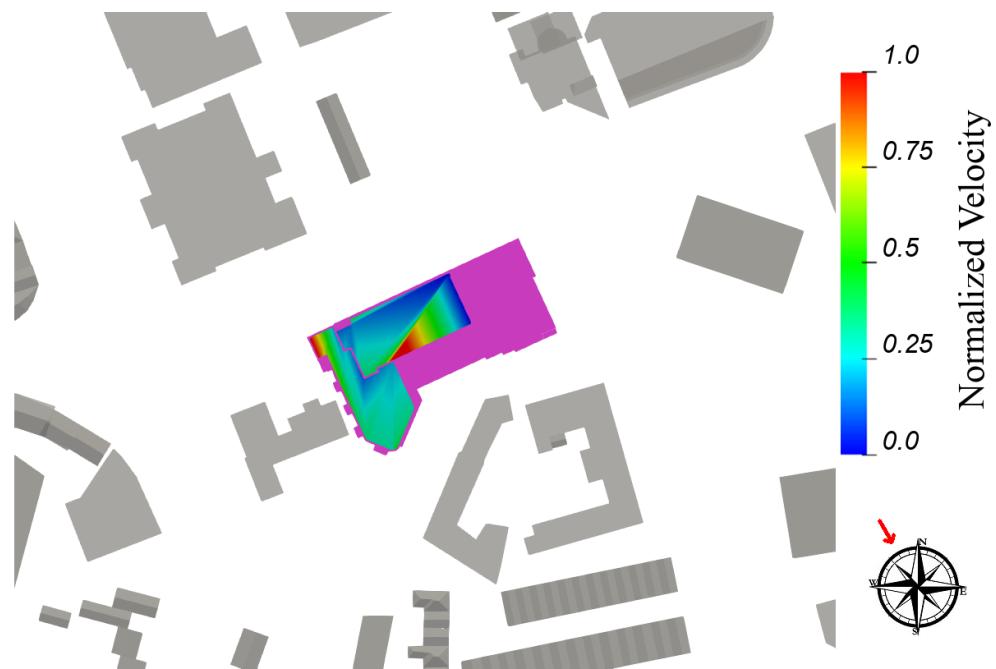


Figure 8.36: Flow Velocity Results at 1.5m above the roof terraces - Wind Direction: 330°

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### 8.2.3 DOWNWASH EFFECT ANALYSIS

Results of wind speeds and their circulations around Anglesea Terrace Residential Development along its height are presented in Figures 8.37 to 8.40 for four selected wind directions ( $00^\circ$ ,  $210^\circ$ ,  $270^\circ$  and  $330^\circ$ ) in order to assess influence of downwash effect.

As mentioned before the downwash effects can happen when the air stream strikes a tall building and a part of it is deflected towards the ground. This downward component is called downwash effect and its intensity depends on the pressure difference driving the wind. The higher the building, the higher this pressure difference can be.

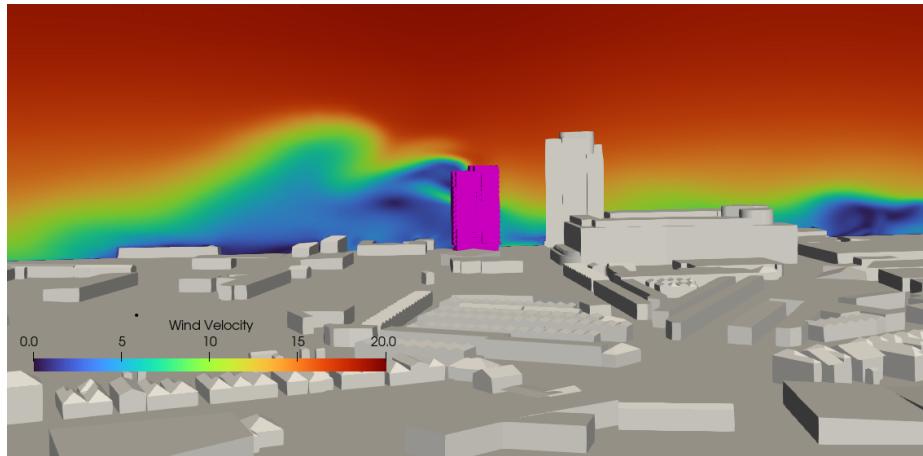


Figure 8.37: Vertical Slice of Flow Velocity Results - Wind Direction:  $0^\circ$

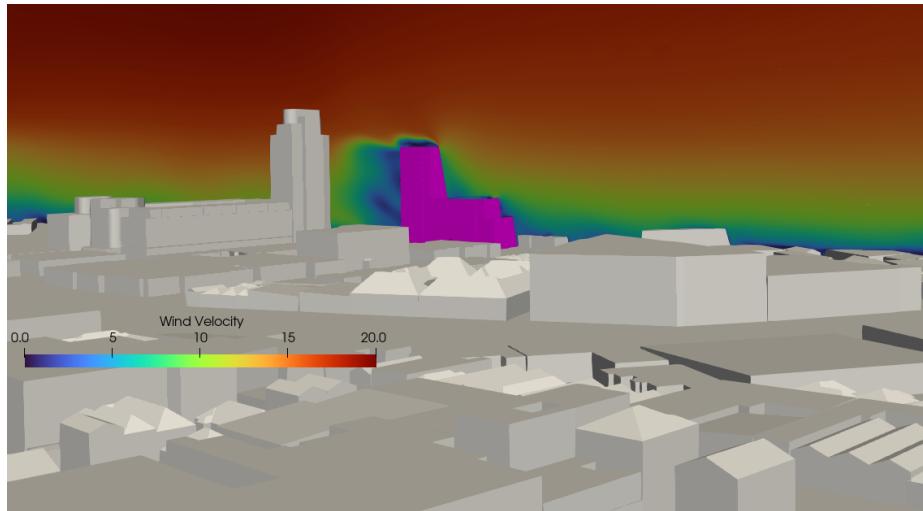


Figure 8.38: Vertical Slice of Flow Velocity Results - Wind Direction:  $210^\circ$

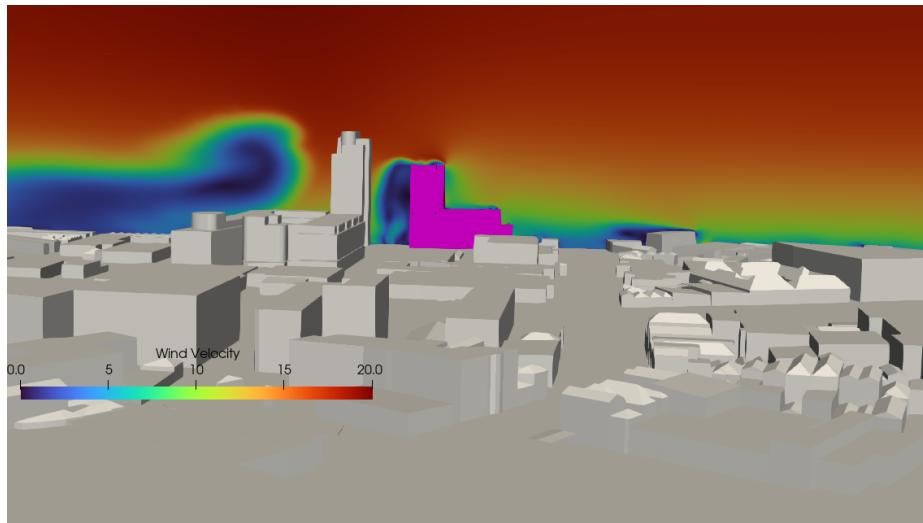


Figure 8.39: Vertical Slice of Flow Velocity Results - Wind Direction:  $270^\circ$

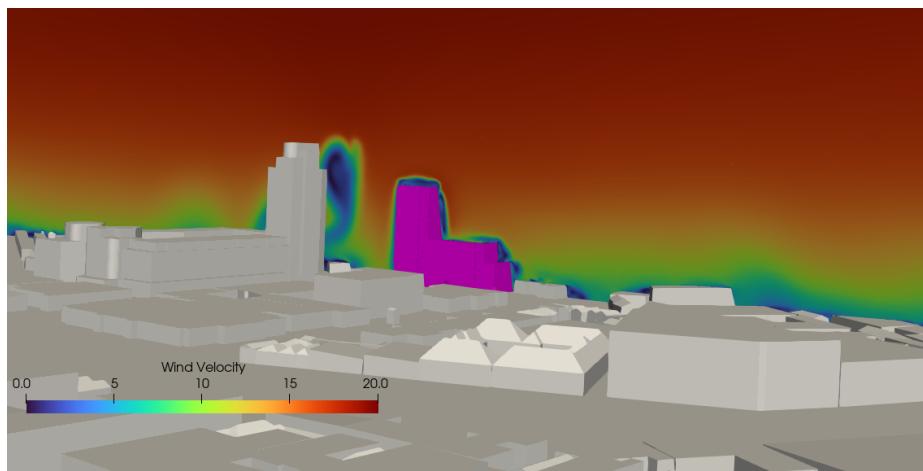


Figure 8.40: Vertical Slice of Flow Velocity Results - Wind Direction:  $330^\circ$

Analyzing the figures above, it can be observed that some downwash effects occur when the wind direction is from the west and the northwest. These effects could be mitigated through the measures discussed and illustrated in Figures 8.47 and 8.48.

#### 8.2.4 PROPOSED DEVELOPMENT WIND MICROCLIMATE - Lawson Criteria

The wind flow results obtained simulating the different direction and wind speeds, are combined with wind frequencies of occurrence to obtain comfort ratings at pedestrian level in all areas included within the model. The comparison of comfort ratings with intended pedestrian activities is shown in the Lawson Comfort and Distress Map that follows.

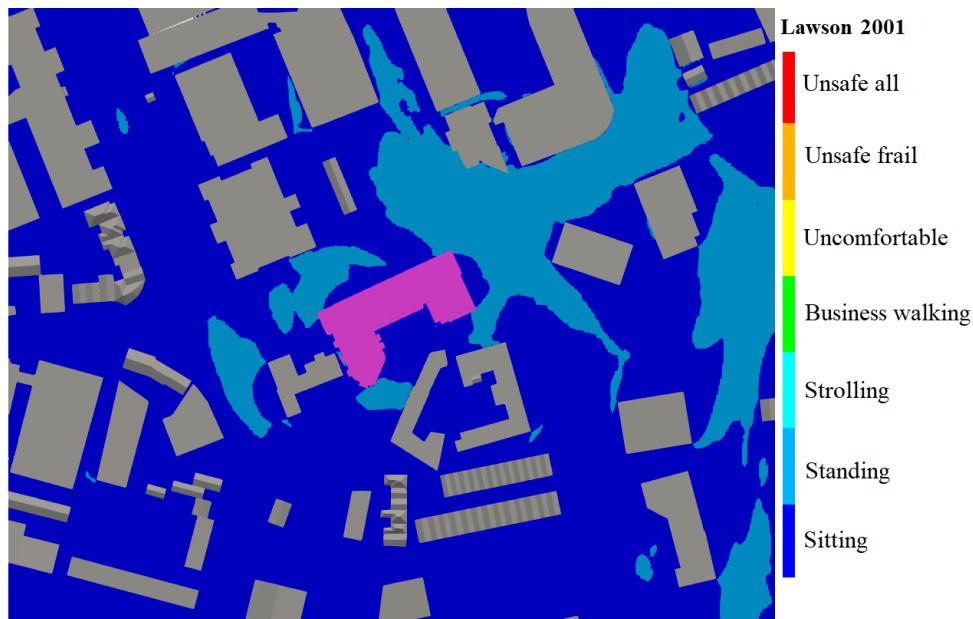


Figure 8.41: Ground Floor - Lawson Discomfort Map - Top View

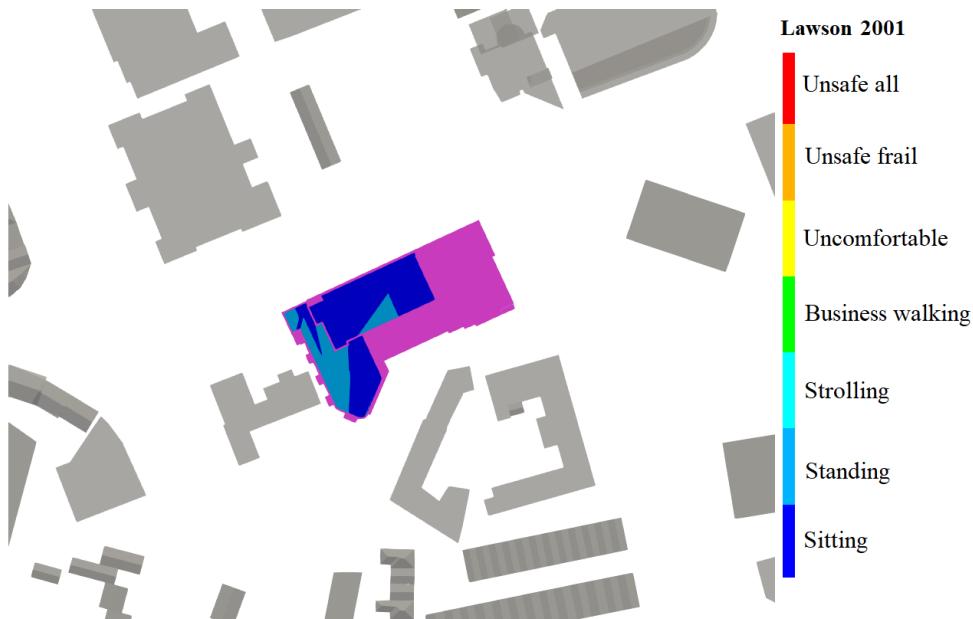


Figure 8.42: Roof Terraces - Lawson Discomfort Map

### 8.2.5 BALCONIES

The comparison of comfort ratings with the intended pedestrian activities is depicted in the Lawson Comfort and Distress Map on the 1.5m balcony floor, as illustrated in Figures 8.43 to 8.46. It is evident that all the balconies are deemed safe for occupants, with no distress areas identified. Wind conditions vary considerably by direction and season, so this should not pose a consistent issue for occupant use. On less favorable days, resident amenities can also serve as an alternative option for outdoor comfort.

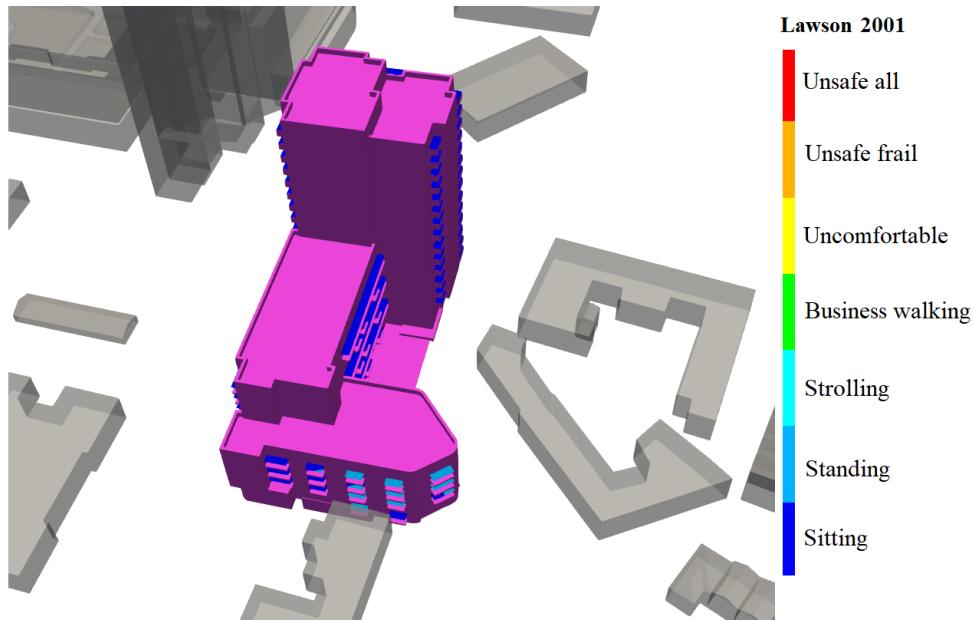


Figure 8.43: Balconies - Lawson Discomfort Map

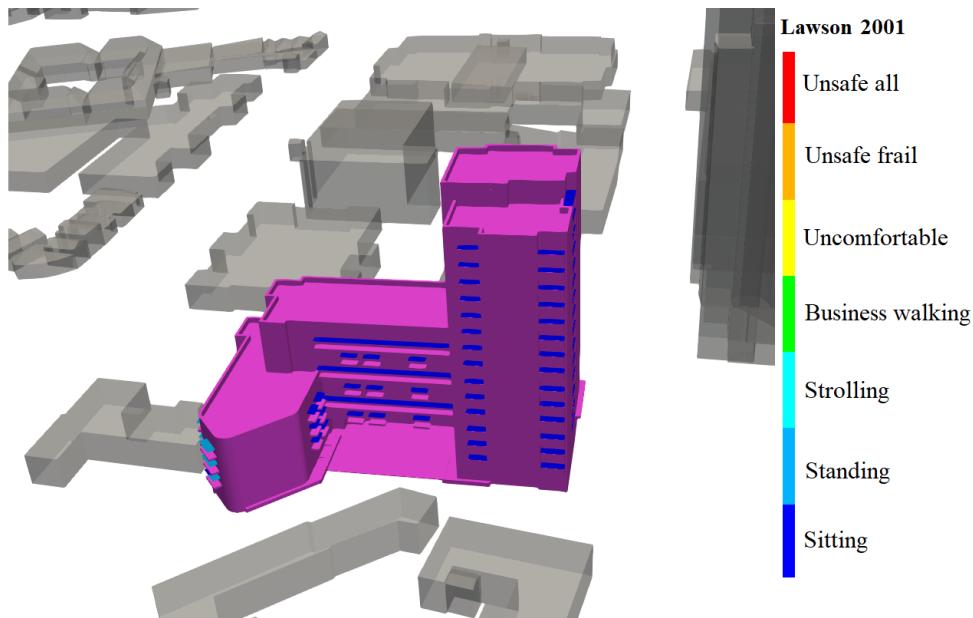


Figure 8.44: Balconies - Lawson Discomfort Map

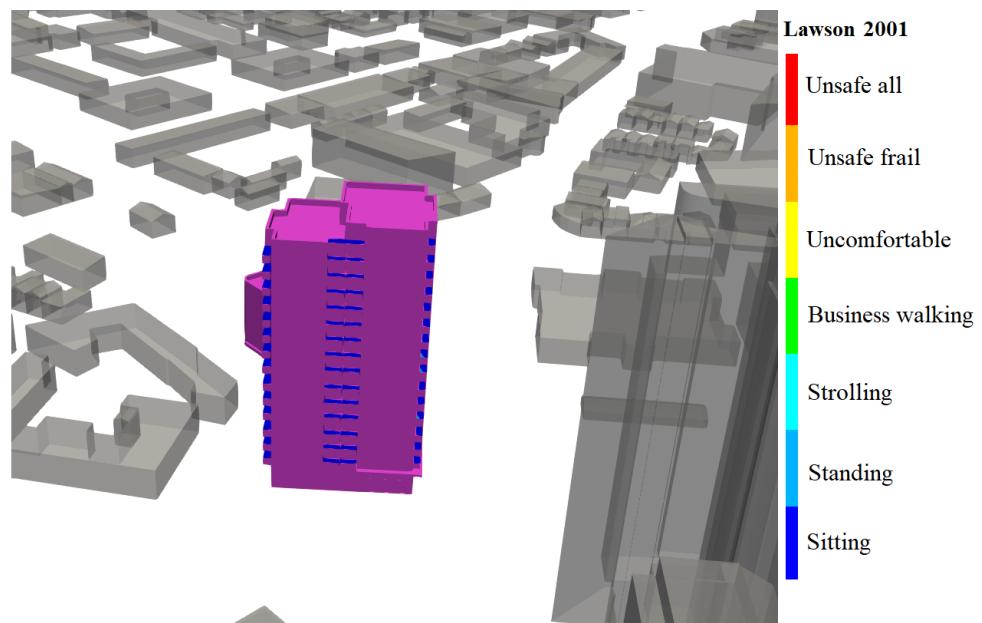


Figure 8.45: Balconies - Lawson Discomfort Map

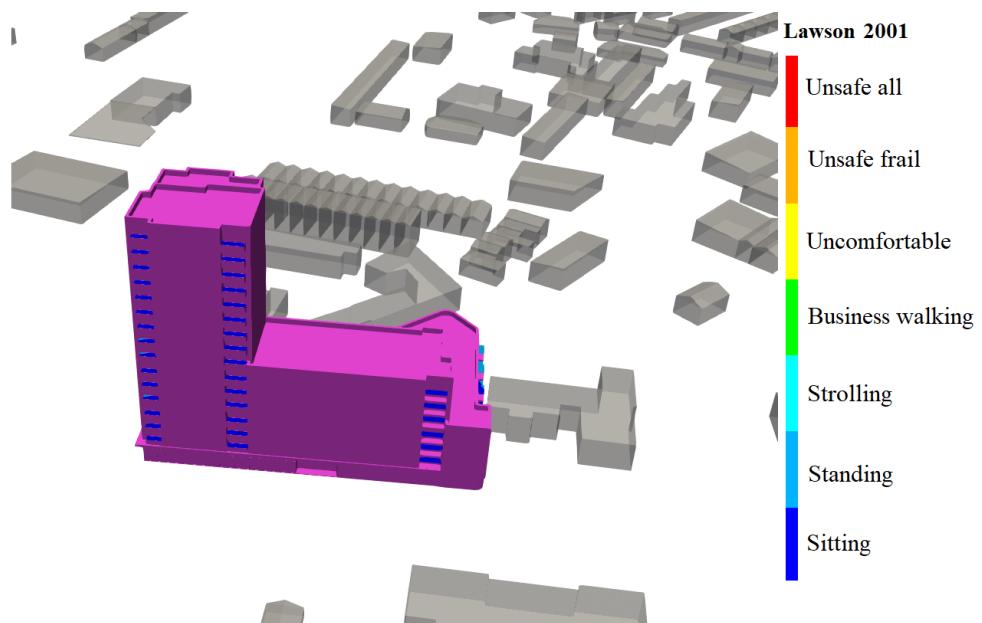


Figure 8.46: Balconies - Lawson Discomfort Map

## 8.2.6 PLANNED MITIGATION

As mentioned in the previous section, there are several wind effects that can occur at the development site, such as downwash, downdraft, and funneling. These phenomena can cause accelerated wind speeds at pedestrian level, leading to potential pedestrian discomfort. In order to address these issues, several mitigation options were evaluated. The chosen options were implemented with the aim of reducing the impact of these wind effects and enhancing pedestrian comfort around the development.

To improve the pedestrian comfort level at the terraces of the development, terrace gardens are implemented which contain various of plants and preservation of existing trees along the walkway on the Northeastern side of the development. These measures collectively contribute to mitigating wind impacts at ground floor and roof terraces of the development as shown in Figures 8.47 and 8.48.

### **The following mitigation measure are implemented to reduce Funneling/Corner effect:**

- Preservation of existing trees along the walkway on the Northeastern side of the development.
- Introduction of plants at Southwestern and southern part of the development to avoid funneling.
- The introduction of additional planting on the roof terrace at Level 7 is recommended.



The “Funneling Effect” in wind analysis refers to the phenomenon where wind speeds are amplified as they flow through a narrow or constricted area, such as between two. This effect occurs because the wind is forced to converge and compress as it moves through the restricted space, resulting in higher velocities and potentially creating turbulent or gusty conditions.

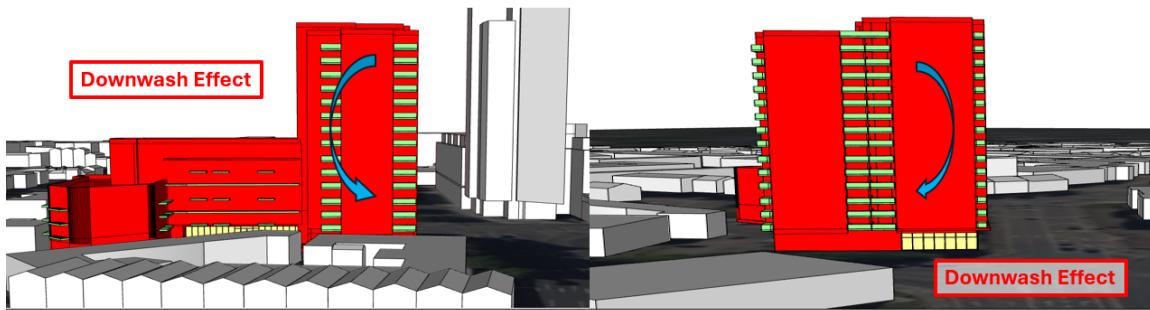
The “Corner Effect” refers to the intensification of wind speeds that can occur at the corners of buildings or other structures, due to the convergence and acceleration of wind flow as it encounters the sharp edges and turns. This effect can create areas of increased turbulence and downdraft.

Figure 8.47: Mitigation Measures for Funneling and Corner Effects

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**Incorporation of landscaping as a mitigation strategy to reduce downwash effect, including:**

- Preservation of existing trees along the walkway on the Northeastern side of the development.
- Introduction of plants at the southern entrance of the development.



The “**Downwash Effect**” refers to the downward movement of air that occurs when wind flows over a building or other obstacle, creating areas of turbulence and potentially leading to strong gusts or localized increases in wind speed at ground level.

Figure 8.48: Mitigation Measures for Downwash Effect

According to the Lawson Map, the receptor area around the development is safe for pedestrians and provides suitable comfort levels for activities such as sitting and standing. It is important to note that the Lawson Map was calculated based on worst-case scenarios without considering trees planting. The addition of trees and plants can help mitigate wind impact and enhance pedestrian/residents comfort levels.

In summary, the following conclusions can be made observing the results of the wind microclimate analysis and comparing the results obtained, under the same wind conditions for the baseline scenario versus the proposed development scenario:

- The assessment of the proposed scenario has shown that no area is unsafe, and no conditions of distress are created by the proposed development.
- All the roads proposed can be used for their intended scope.
- Both terraces (Terraces I and II) are suitable for sitting/standing. It is important to note that fluctuations in velocity on rooftop terraces may lead to door slamming issues. Therefore, it is recommended to consider such conditions in terrace design. Possible means of reducing the risk of door slamming include installing door actuators, using automatic or sliding doors, etc.
- The wind microclimate of the proposed development is comfortable and usable for pedestrians.

As a result of the proposed development construction, the wind on the surrounding urban context maintains the suitability of the surrounding urban environment for its intended purpose.

Table 8.1 presents the pedestrian comfort levels for various on-site and off-site locations. As shown in the table, none of the areas are deemed unsafe, and all on-site receptors around the development are suitable for at least standing comfort level.

Table 8.1: Pedestrian Comfort Levels versus Proposed pedestrian activities

Reference point	Description	Sitting	Standing	Strolling	Business walking	Distress and Safety
1.	Area in the southwest direction	Tolerable	Acceptable	Acceptable	Acceptable	Safe.
2.	Open Area in Corner	Tolerable	Acceptable	Acceptable	Acceptable	Safe.
3.	Open Area towards the Entrance	Acceptable	Acceptable	Acceptable	Acceptable	Safe.
4.	Entrance	Acceptable	Acceptable	Acceptable	Acceptable	Safe.
5.	Northern Edge Footpath	Acceptable	Acceptable	Acceptable	Acceptable	Safe.
6.	Northeastern Footpath	Tolerable	Acceptable	Acceptable	Acceptable	Safe.
I	Terrace at 4th Floor	Tolerable	Acceptable	Acceptable	Acceptable	Safe.
II	Terrace at 7th Floor	Tolerable	Acceptable	Acceptable	Acceptable	Safe.
A.	Intersection of Old Station Rd., Anglesea St. and Copley St.	Tolerable	Acceptable	Acceptable	Acceptable	Safe.
B.	Anglesea Street	Tolerable	Acceptable	Acceptable	Acceptable	Safe.
C.	Intersection of Anglesea St. and Anglesea Terrace	Acceptable	Acceptable	Acceptable	Acceptable	Safe.
D.	Intersection of Anglesea Terrace and Railway Cottages	Tolerable	Acceptable	Acceptable	Acceptable	Safe.
E.	Anglesea Terrace Cul de Sac	Acceptable	Acceptable	Acceptable	Acceptable	Safe.
F.	S City Link Rd	Tolerable	Acceptable	Acceptable	Acceptable	Safe.
G.	Intersection of Old Station Rd, S City Link Rd and Eglinton St.	Tolerable	Acceptable	Acceptable	Acceptable	Safe.
H.	Old Station Road	Tolerable	Acceptable	Acceptable	Acceptable	Safe.

Tables 8.2 and 8.3 show the intended baseline and proposed wind conditions on-site as well as some potential off-site receptors around the development. Locations of the ground amenity, the courtyards areas listed in these Tables are indicated in Figure 8.50

Table 8.2: Significance Impact of the Proposed Development Versus Baseline Conditions for Comfort - On Site Receptors

On-Site Potential Receptors	Baseline Conditions	Proposed Development Conditions	Impact Significance
1. Area in the southwest direction	Suitable for Sitting.	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
2. Open Area in Corner	Suitable for Sitting.	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
3. Open Area towards the Entrance	Suitable for Sitting.	Suitable for Sitting. (Safe/No distress)	Negligible
4. Entrance	Suitable for Sitting.	Suitable for Sitting. (Safe/No distress)	Negligible
5. Northern Edge Footpath	Suitable for Sitting.	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
6. Northeastern Footpath	Suitable for Sitting.	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
Terrace I (4th floor)	-	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
Terrace II (7th floor)	-	Suitable for Sitting/Standing. (Safe/No distress)	Negligible

Table 8.3: Significance Impact of the Proposed Development Versus Baseline Conditions for Comfort - Off Site Receptors

Off-Site Potential Receptors	Baseline Conditions	Proposed Development Conditions	Impact Significance
A. Intersection of Old Station Rd., Anglesea St. and Copley St.	Suitable for Sitting.	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
B. Anglesea Street	Suitable for Sitting.	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
C. Intersection of Anglesea St. and Anglesea Terrace	Suitable for Sitting.	Suitable for Sitting. (Safe/No distress)	Negligible
D. Intersection of Anglesea Terrace and Railway Cottages	Suitable for Sitting.	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
E. Anglesea Terrace Cul de Sac	Suitable for Sitting.	Suitable for Sitting. (Safe/No distress)	Negligible
F. S City Link Rd	Suitable for Sitting.	Suitable for Sitting/Standing. (Safe/No distress)	Negligible
G. Intersection of Old Station Rd, S City Link Rd and Eglinton St.	Suitable for Sitting/Standing.	Suitable for Standing. (Safe/No distress)	Negligible
H. Old Station Road	Suitable for Sitting.	Suitable for Sitting/Standing. (Safe/No distress)	Negligible

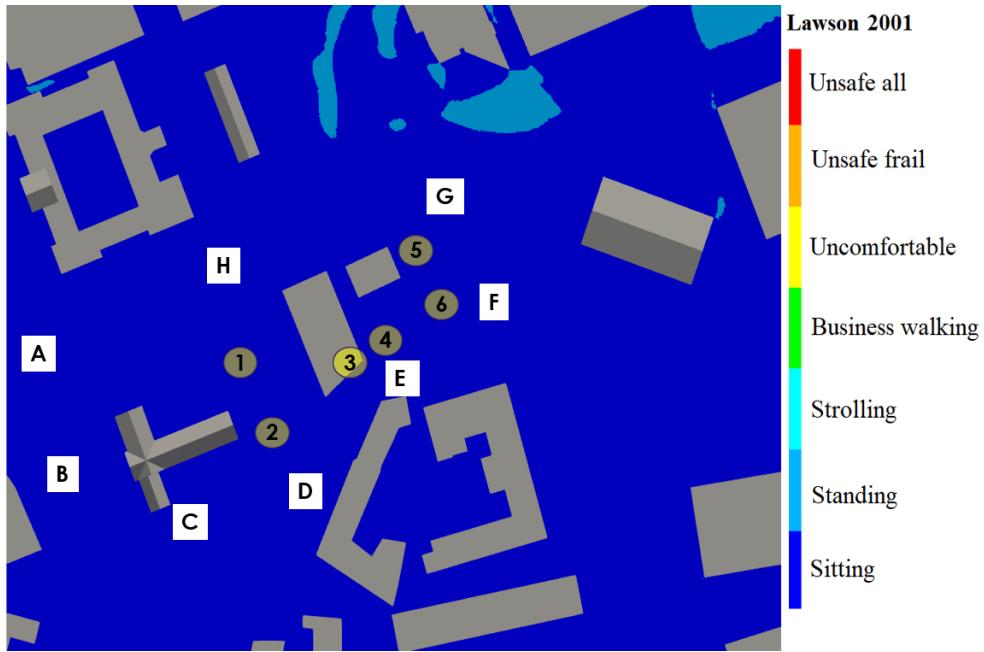


Figure 8.49: Locations of the Receptors on the Ground for Baseline

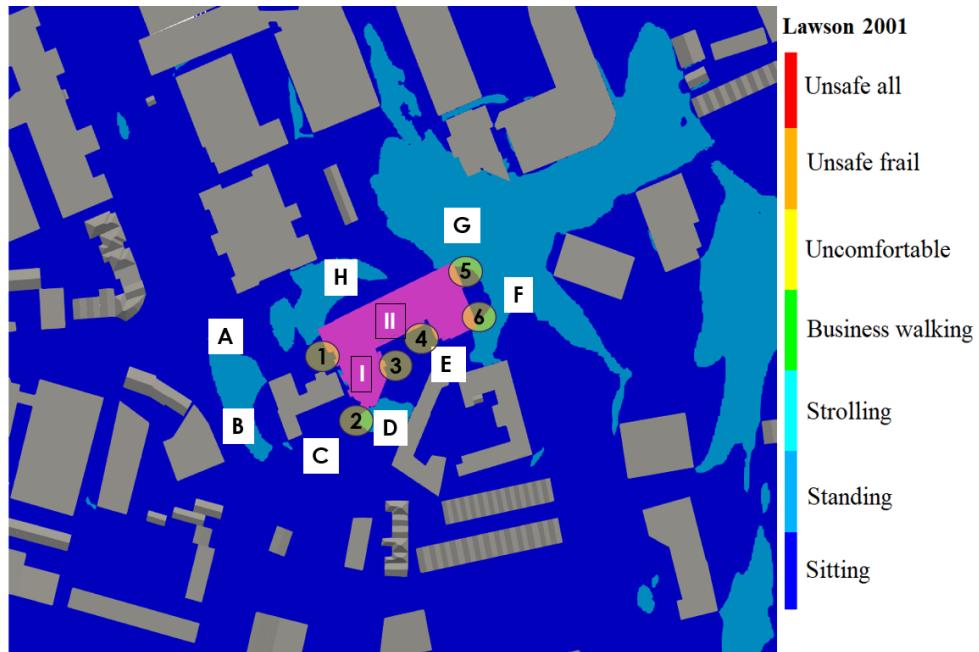


Figure 8.50: Locations of the Receptors on the Ground and Terraces for Proposed Development

As shown in Tables 8.2 and 8.3, there are no distress area for pedestrians including frail users and cyclists. Furthermore, the site and surrounding urban areas are safe for all users.

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## 9. CONCLUSIONS

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## CONCLUSIONS and COMMENTS ON MICROCLIMATE STUDY

This report presents the CFD modelling assumptions and results of Wind and Microclimate Modelling of Anglesea Terrace Residential Development, Anglesea Terrace, Old Station Road, Cork.

This study has been carried out to identify the possible wind patterns around the area proposed, under mean and peak wind conditions typically occurring in Cork, and also to assess impacts of the wind on pedestrian levels of comfort/distress.

The results of this wind microclimate study are utilized by Henry J. Lyons to configure the optimal layout for Anglesea Terrace Residential Development for the aim of achieving a high-quality environment for the scope of use intended of each areas/building (i.e. comfortable and pleasant for potential pedestrian) and not to introduce any critical wind impact on the surrounding areas and on the existing buildings.

- The wind profile was built using the annual average of meteorology data collected at Cork Airport Weather Station purchased from Meteoblue. The local wind speed was determined from CFD simulations with combination of the parameters inside Weibull probability distribution function, which obtained from historical meteorological data recorded 10m above ground level at Cork Airport.
- A 12-discrete set of wind direction is used in order to evaluate the probability of exceedance at any given threshold velocity. It is found that the prevailing wind direction in the south-west has the largest contribution of the discomfort exceedance probability.
- Microclimate Assessment of Anglesea Terrace Residential Development and its surrounding environment was performed utilizing a CFD (Computational Fluid Dynamics) methodology.
- The evaluation of the proposed scenario indicates that the planned development aligns with the Lawson Comfort Criteria, confirming that no areas are unsafe and the proposed development does not create conditions of distress. All the ground amenities outlined in the report can be utilized according to their intended scope.
- The analysis of wind speed results and Lawson map at a height of 1.5 meters above the terrace reveals that both terraces (Terraces I and II) are suitable for sitting/standing. It is important to note that fluctuations in velocity on rooftop terraces may lead to door slamming issues. Therefore, it is recommended to consider such conditions in terrace design. Possible means of reducing the risk of door slamming include installing door actuators, using automatic or sliding doors, etc.
- The Lawson Comfort and Distress Map at 1.5m above the balconies indicates that all balconies are safe for occupants, with no identified areas of distress. Wind conditions vary considerably by direction and season, so this should not pose a consistent issue for occupant use. On less favorable days, resident amenities can also serve as an alternative option for outdoor comfort.
- The following mitigation measures will be implemented to further improve pedestrian comfort around the development:

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- *Preserving the existing trees along the walkway on the northeastern side of the development:*

The presence of these existing trees along the walkway enhances the comfort for pedestrians.

- *Introducing plants on southern entrance and southwestern part of the development:*

These additional plants will help reduce wind speed, increasing comfort levels in all ground amenities of the development.

- *A sedum roof on the 4th floor is already a great addition and incorporating some additional planting on Level 7 is also advisable.*

The introduction of terrace gardens and small plants will further improve the wind comfort level on the terraces and also help reduce corner effects.

- As a result of the proposed development construction, the wind on the surrounding urban context remains suitable for the intended use when compared with the baseline situation.
- The proposed development does not impact or give rise to negative or critical wind speed profiles at the nearby adjacent roads, or nearby buildings. Moreover, in terms of distress, no critical conditions were found for “Frail persons or cyclists” and for members of the “General Public” in the surrounding of the development.

Therefore, the CFD study carried out has shown that under the assumed wind conditions typically occurring within Cork for the past 15 years:

- **The development is designed to be a high-quality environment for the scope of use intended of each areas/building (i.e. comfortable and pleasant for potential pedestrian).**
- **The development does not introduce any critical impact on the surrounding buildings, or nearby adjacent roads.**

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## 10. REFERENCES

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